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Evaluation of
Prototype General Purpose Visor Concepts

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ABSTRACT

The incidence of eye and facial injuries has increased over the past century; these injuries can account for a sizeable proportion of casualties. The Clothe the Soldier (CTS) project is developing an integrated two-part system of protection to protect the eyes from low energy fragments, particles, laser, solar and UV radiation (ballistic eyewear) and to protect the eyes and face from high-energy fragments (ballistic visor). A Human Factors 4-day field trial of a range of visor concepts was conducted at CFB Petawawa over the period 17-20 May, 1999 in order to better understand user requirements, investigate utility and usability issues associated with visor wear across a range of tasks and conditions and assist in the development of HF-related requirements and design specifications. Twenty regular force infantry soldiers were required to undertake a battery of human factors tests while wearing up to four different visor conditions in a repeated measures design: two protection levels (V_{50} of 220 m/s and 450 m/s) and two shapes (flat and curved). All tests included a no visor condition as a baseline control. During each test, the order of conditions was balanced among participants. Human factors tests included clinical tests of visual performance, static military vision tests, performance of select obstacle course, range firing, and battle tasks, equipment / weapons / vehicle compatibility clash, and maintainability. Data collection included questionnaires, focus groups, performance measures and HF observer assessments.

Soldiers indicated that the most important assessment criteria for a general-purpose visor were weapon compatibility and visual performance. The visor posed a number of concerns in these areas. Participants rated visor use with the C7A1 rifle as unacceptable due to the slight delay necessary to position the nasal cutout over the rifle butt to achieve a full sight picture. While annoying, participants quickly learned to adjust to the extra head movement needed during sighting to accommodate the visor. Visual performance was another concern among participants. Visual acuity tests confirmed that all of the visors tested produced a small but significant drop in visual performance. While participants did rate the visual performance aspects (e.g. visual sharpness, field of view, distortion, depth perception, etc.) of visors as low, the thin visors were generally rated significantly more favourably than the thick visor designs. In most evaluations, the thick visors were rated as unacceptable. In addition to the visual performance differences between the thin and thick visors, participants also noted additional musculo-skeletal stress and fatigue at the neck associated with the higher load forces imposed by the thick visors. Participants also expressed considerable concern about the ease with which an enemy observer might detect a highly reflective visor. Focus group discussion identified situations for which the Curved Thin visor would be most suitable. A family of visors was recommended to accommodate the range of applications needed. Soldiers also identified a range of modifications to improve weapon compatibility and a host of visual performance parameters.

RESUME

Au cours du dernier siècle, l’incidence des blessures aux yeux et au visage a augmenté et correspond maintenant à une proportion considérable du nombre total de blessures. Dans le cadre du projet « Habillez le soldat » (HLS), on développe un système intégré à deux parties pour protéger les yeux contre les fragments, les particules et les rayons laser, solaires et UV à faible énergie, (lunettes balistiques) et pour protéger les yeux et le visage contre les fragments à haute énergie (visière balistique).

Un essai sur le terrain de quatre jours pour évaluer des facteurs humains d’une gamme de concepts de visières a été mené à la BFC Petawawa du 17 au 20 mai 1999 afin de mieux comprendre les exigences de l’utilisateur, d’étudier les questions d’utilité et d’utilisabilité associées au port des visières pour une variété de tâches et de conditions et d’aider dans l’élaboration d’exigences et de spécifications de conception liées à des facteurs humains. Vingt fantassins de la force régulière ont été chargés de mener une batterie d’essais portant sur des facteurs humains pendant qu’ils portaient jusqu’à quatre types de visières différents selon un protocole de mesures répétées : deux niveaux de protection (V_{50} de 220 m/s et de 450 m/s) et deux formes (plate et incurvée). Tous les essais comprenaient une condition sans visière à titre de contrôle de référence. Pendant chaque essai, l’ordre des conditions était équilibré parmi les participants. Les essais portant sur des facteurs humains comprenaient des essais cliniques de la performance visuelle, des essais d’acuité visuelle statique militaires, la performance sur un parcours du combattant sélectionné, la performance au champ de tir et en tâches de combat, la compatibilité avec l’équipement, les armes et le véhicule et la maintenabilité. La collecte des données s’est faite au moyen de questionnaires, de groupes de discussion, de mesures de performance et d’évaluations par les observateurs des facteurs humains.

Les soldats ont indiqué que les critères d’évaluation les plus importants pour la visière polyvalente étaient la compatibilité avec les armes et la performance visuelle. La visière donnait lieu à un certain nombre de préoccupations à ces égards. Les participants ont jugé l’utilisation d’une visière avec le fusil C7A1 inacceptable à cause du léger retard nécessaire pour positionner l’échancrure nasale par-dessus la crosse du fusil pour obtenir une image viseur intégrale. La performance visuelle était une autre préoccupation parmi les participants. Bien que les participants aient attribué une faible cote aux aspects de performance visuelle (p. ex. acuité visuelle, champ de vision, distorsion et perception tridimensionnelle) des visières, les visières minces ont généralement obtenu une meilleure cote que les visières épaisses. Dans la plupart des évaluations, les visières épaisses ont été cotées inacceptables. En plus des différences de performance visuelle entre les visières minces et les visières épaisses, les participants ont également noté des contraintes et de la fatigue musculo-squelettiques au niveau du cou attribuables aux charges supérieures imposées par les visières épaisses. En outre, les participants ont exprimé beaucoup d’inquiétude au sujet de la facilité avec laquelle un observateur ennemi pourrait détecter une visière à haute réflexion. Seules les visières minces étaient considérées comme une solution acceptable pour une visière polyvalente. Au chapitre des visières minces, le modèle incurvé était préféré (78 % des participants) au modèle plat (22 %).

Les groupes de discussion ont défini des situations auxquelles la visière mince incurvée conviendrait le mieux. Une famille de visières a été recommandée pour répondre à la gamme d’applications nécessaires. Les soldats ont également défini une série de modifications pour améliorer la compatibilité avec les armes et une kyrielle de paramètres de performance visuelle.

EXECUTIVE SUMMARY

Epidemiological data, collected from various conflicts over the last 150 years, suggests that the incidence of eye and facial injuries is increasing and can account for a sizeable proportion of casualties (~12%). The CF Land Force currently employs two in-service, ballistic eyewear protection devices: Sand/Wind/Dust Goggles (with ballistic insert) and Glendale Safety Spectacles. Both devices provide some degree of ballistic eye protection (V_{50}~150 m/s) but are not intended to provide protection for higher energy fragments or to provide facial protection.

To address this deficiency, the Clothe the Soldier (CTS) project is developing an integrated two-part system of protection to protect the eyes from low energy fragments, particles, laser, solar and UV radiation (ballistic eyewear) and to protect the eyes and face from high-energy fragments (ballistic visor). As part of the ballistic visor project, the CTS project required HF input to the visor requirements and design specifications for use in future procurement activities. A Human Factors (HF) field trial was proposed as the best means of assessing the factors in visor design which affect visual performance. A HF trial also provided an opportunity to further investigate the suitability of a ballistic visor for use in the missions identified in the concept of operations.

A four-day field trial was undertaken at CFB Petawawa over the period of 17 – 20 May 1999. Twenty regular force infantry soldiers were required to undertake a battery of human factors tests while wearing up to four different visor conditions in a repeated measures design: two protection levels (V_{50} of 220 m/s and 450 m/s) and two shapes (flat and curved). All tests included a no visor condition as a baseline control. During each test, the order of conditions was balanced among participants. Human factors tests included clinical tests of visual performance, static military vision tests, performance of select obstacle course, range firing, and battle tasks, equipment / weapons / vehicle compatibility clash, and maintainability. Data collection included questionnaires, focus groups, performance measures and HF observer assessments.

Soldiers indicated that the most important assessment criteria for a general-purpose visor were weapon compatibility and visual performance. The visor posed a number of concerns in these areas. Participants rated visor use with the C7A1 rifle as unacceptable due to the slight delay necessary to position the nasal cutout over the rifle butt to achieve a full sight picture. While annoying, participants quickly learned to adjust to the extra head movement needed during sighting to accommodate the visor. Visual performance was another concern among participants. Visual acuity tests confirmed that all of the visors tested produced a small but significant drop in visual performance. While participants did rate the visual performance aspects (e.g. visual sharpness, field of view, distortion, depth perception, etc.) of visors as low, the thin visors were generally rated significantly more favourably than the thick visor designs. In most evaluations, the thick visors were rated as unacceptable. In addition to the visual performance differences between the thin and thick visors, participants also noted additional musculo-skeletal stress and fatigue at the neck associated with the higher load forces imposed by the thick visors. Participants also expressed considerable concern about the ease with which an enemy observer might detect a highly reflective visor.

Only the thin visors were seen as an acceptable design solution for a general-purpose visor. For the thin visors, the curved design was preferred (78% of participants) to the flat

design (22%). During the focus group discussion, participants indicated that the Curved Thin visor would be suitable for driving vehicles, riot control or reaction to a hostile crowd, fighting in built up areas, and occupying a defensive position. Most participants (72%) would be willing to accept the Curved Thin visor for conventional warfare tasks if the concept of operations allowed them to raise the visor into a fixed “up” position when not in a threat situation and when using certain weapons (e.g. Carl Gustav). All participants agreed that general acceptance of any visor would improve with experience.

During the Exit focus group discussion participants suggested several modifications to improve the Curved Thin visor design in the areas of ventilation, anti-fogging, visual performance, and anti-glare. As well, participants suggested that the Army should consider a family of visors. The half-face coverage of the Curved Thin visor was considered acceptable for high activity tasks typical of conventional warfare but they stressed the need for more special-to-purpose variants to meet the range of task demands and threats possible in today’s medium and low intensity conflicts. Examples included a full-face variant for riot control tasks and a selection of visors with different protective coatings (e.g. solar tinting, laser coatings, etc.).

SOMMAIRE

Des données historiques, collectées de divers conflits au cours des 150 dernières années, semblent indiquer que l'incidence des blessures aux yeux et au visage augmente et correspond maintenant à une proportion considérable (~12 %) du nombre total de blessures. La Force terrestre des FC a actuellement deux dispositifs de protection oculaire balistique en service : des lunettes étanches au sable, au vent et à la poussière (avec écran balistique amovible) et les lunettes de sûreté Glendale. Les deux dispositifs offrent un certain degré de protection balistique des yeux (V_{50} de ~150 m/s), mais ne sont pas conçus pour assurer une protection contre les fragments à haute énergie, ni pour assurer la protection du visage.

Pour combler cette lacune, on développe, dans le cadre du projet « Habillez le soldat » (HLS), un système intégré à deux parties pour protéger les yeux contre les fragments, les particules et les rayons laser, solaires et UV à faible énergie, (lunettes balistiques) et pour protéger les yeux et le visage contre les fragments à haute énergie (visière balistique). Aux fins du projet de visière balistique, le projet HLS avait besoin de données sur le facteurs humains pour établir les exigences et spécifications de conception de visières aux fins des activités d'approvisionnement futures. Un essai sur le terrain portant sur des facteurs humains (FH) a été proposé comme le meilleur moyen d'évaluer les facteurs de conception de la visière qui influent sur la performance visuelle. Un essai portant sur des FH permettrait également d'étudier davantage l'adéquation d'une visière balistique à l'utilisation lors des missions définies dans le concept des opérations.

Un essai sur le terrain de quatre jours a été mené à la BFC Petawawa du 17 au 20 mai 1999. Vingt fantassins de la force régulière ont été chargés de mener une batterie d'essais portant sur des facteurs humains pendant qu'ils portaient jusqu'à quatre types de visières différents selon un protocole de mesures répétées : deux niveaux de protection (V_{50} de 220 m/s et de 450 m/s) et deux formes (plate et incurvée). Tous les essais comprenaient une condition sans visière à titre de contrôle de référence. Pendant chaque essai, l'ordre des conditions était équilibré parmi les participants. Les essais portant sur des facteurs humains comprenaient des essais cliniques de la performance visuelle, des essais d'acuité visuelle statique militaires, la performance sur un parcours du combattant sélectionné, la performance au champ de tir et en tâches de combat, la compatibilité avec l'équipement, les armes et le véhicule et la maintenabilité. La collecte des données s'est faite au moyen de questionnaires, de groupes de discussion, de mesures de performance et d'évaluations par les observateurs des facteurs humains.

Les soldats ont indiqué que les critères d'évaluation les plus importants pour la visière polyvalente étaient la compatibilité avec les armes et la performance visuelle. La visière donnait lieu à un certain nombre de préoccupations à ces égards. Les participants ont jugé l'utilisation d'une visière avec le fusil C7A1 inacceptable à cause du léger retard nécessaire pour positionner l'échancrure nasale par-dessus la crosse du fusil pour obtenir une image viseur intégrale. Le mouvement de tête supplémentaire nécessaire pendant la mise en joue avec visière était dérangeant, mais les participants s'y sont adaptés rapidement. La performance visuelle était une autre préoccupation parmi les participants. Les essais d'acuité visuelle ont confirmé que toutes les visières essayées produisaient une baisse légère, mais notable, de la performance visuelle. Bien que les participants aient attribué une faible cote aux aspects de performance visuelle (p. ex. acuité visuelle, champ de vision, distorsion et perception tridimensionnelle) des visières, les visières minces ont généralement obtenu une meilleure cote que les visières épaisses. Dans la plupart des évaluations,

les visières épaisses ont été cotées inacceptables. En plus des différences de performance visuelle entre les visières minces et les visières épaisses, les participants ont également noté des contraintes et de la fatigue musculo-squelettiques au niveau du cou attribuables aux charges supérieures imposées par les visières épaisses. En outre, les participants ont exprimé beaucoup d'inquiétude au sujet de la facilité avec laquelle un observateur ennemi pourrait détecter une visière à haute réflexion.

Seules les visières minces étaient considérées comme une solution acceptable pour une visière polyvalente. Au chapitre des visières minces, le modèle incurvé était préféré (78 % des participants) au modèle plat (22 %). Pendant les discussions de groupe, les participants ont indiqué que la visière mince incurvée conviendrait à la conduite de véhicules, à la répression d'émeutes ou à la réaction à une foule hostile, au combat en zone urbaine et à l'occupation d'une position défensive. La plupart (72 %) des participants seraient prêts à accepter la visière mince incurvée pour des tâches de guerre conventionnelle si le concept des opérations leur permettait de relever la visière, puis de l'immobiliser dans une situation sans menace et aux fins de l'utilisation de certaines armes (p. ex. le canon Carl Gustav). Tous les participants convenaient que l'acceptation généralisée de toute visière s'améliorerait avec l'expérience.

Pendant la dernière discussion de groupe, les participants ont suggéré plusieurs modifications pour améliorer la conception de la visière mince incurvée à l'égard de la compatibilité avec les armes, de l'aération, du désembuage, de la performance visuelle et de l'antiéblouissement. De plus, les participants ont suggéré que l'Armée de terre envisage une famille de visières. La couverture de la moitié du visage qu'offre la visière mince incurvée était considérée comme acceptable pour les tâches de grande activité typiques de la guerre conventionnelle, mais les participants ont souligné le besoin de variantes mieux adaptées à l'usage pour répondre à la gamme d'exigences de tâche et de menaces possibles dans les conflits de moyenne et de faible intensité de nos jours. Les exemples comprenaient une variante plein visage pour les tâches de répression d'émeutes et une sélection de visières avec différents revêtements protecteurs (p. ex. teinture antisolaire, revêtements antilaser).

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

1. BACKGROUND

Epidemiological data, collected from various conflicts over the last 150 years (Figure 1), suggests that the incidence of eye and facial injuries is increasing and can account for a sizeable proportion of casualties (~12%). This steady increase in eye injuries has been associated with the proliferation of fragmentation weapon use in urban and high mobility environments where the occurrence of high velocity, low mass primary and secondary fragments is high. Given the high vulnerability of the eye itself, even small fragments that are harmless to other areas of the body can readily produce ocular casualties.

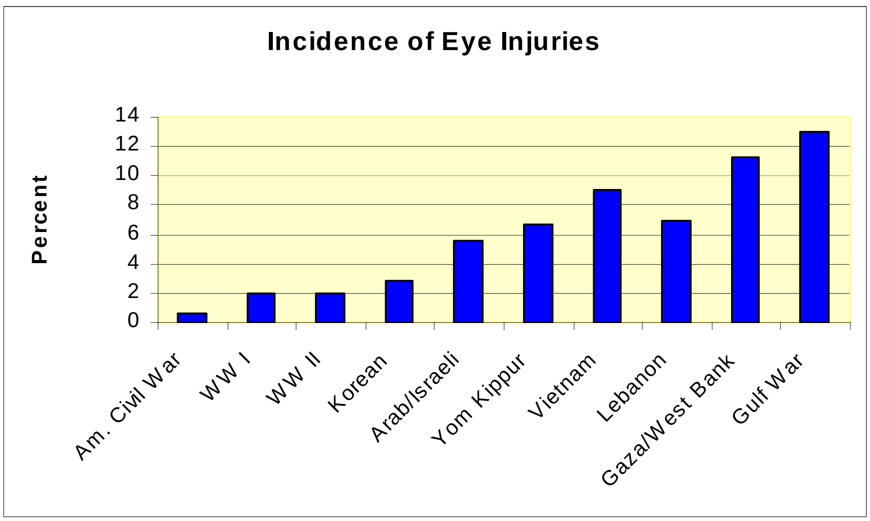


Figure 1: Historical Incidence of Eye Injury

The Canadian Forces (CF) does not possess a singular or integrated ocular or facial protection system. Currently, CF soldiers are issued facial and ocular protective equipment only in very select circumstances. These include UN and NATO deployment and have included Sand/Wind/Dust Goggles (with ballistic insert) and Glendale Safety Spectacles. Both devices provide some degree of ballistic eye protection (V_{50}~150 m/s) but are not intended to provide protection for higher energy fragments or to provide facial protection.

To address this deficiency, the Clothe the Soldier (CTS) project is developing an integrated two-part system of protection to protect the eyes from low energy fragments, particles, laser, solar and UV radiation (ballistic eyewear) and to protect the eyes and face from high-energy fragments (ballistic visor). As part of the ballistic visor project, the CTS team requires HF input to the visor requirements and design specifications for use in future procurement activities.

As part of this initiative, an earlier trial of a prototype Visor Attachment Sub-System (VASS) included ½ face and full-face visors in a squared, box-shaped design for the purposes of gaining insight into visor usability issues. The ½ face visors were included at two protection levels (220 m/s and 450 m/s) (reference A). These visors are considered to provide low and medium levels of protection, which can also be inferred from the thickness of the polycarbonate visor lenses. Many of the comments from the trial suggested that the suitability of a ballistic visor depended on its intended mission use. To better define the mission use issues, DLR prepared a concept of operations for visor use (reference B) to outline the most likely intended missions for a general-purpose visor.

Since visual performance was seen to be a primary driver in user acceptance and task performance, a Human Factors (HF) field trial was proposed as the best means of assessing the factors in visor design which affect visual performance. A HF trial also provided an opportunity to further investigate the suitability of a ballistic visor for use in the missions identified in the concept of operations.

1.1 Aims

The aim of this project was to identify critical HF issues and user requirements for use in the visor concept design and the development of a future Ballistic Visor SOR. As well, this trial was to investigate the concept of operations for the employment of ballistic visors, based on the draft Concept of Operations document prepared by DLR.

2. METHOD

2.1 Overview

The following description provides a general overview of the trial method. Further details are provided in subsequent sections.

A four-day field trial was undertaken at CFB Petawawa over the period of 17 – 20 May 1999. Twenty regular force infantry soldiers were required to undertake a battery of human factors tests while wearing up to four different visor conditions in a repeated measures design: two protection levels (V_{50} of 220 m/s and 450 m/s) and two shapes (flat and curved). All tests included a no visor condition as a baseline control. During each test, the order of conditions was balanced among participants. Human factors tests included clinical tests of visual performance, static military vision tests, performance of select obstacle course, range firing, and battle tasks, equipment / weapons / vehicle compatibility clash, and maintainability. Data collection included questionnaires, focus groups, performance measures and HF observer assessments.

Table 1 outlines the four-day trial schedule.

17 – 20 May 1999				
	Monday (day 1)	**Tuesday** (day 2)	**Wednesday** (day 3)	**Thursday** (day 4)
AM	Initial Briefing Trial Outline Acuity Testing Visor Issue FOV confirm	Obstacle Course Compatibility Stands	C7 Rifle Range • Run-down drills Jungle Lane	Paint-ball Capture the Flag
Lunch				
AFT	Clinical Tests • FOV/Acuity • Stereoacuity • Rifle Targeting Anthropometry	Vehicle Driving OP Surveillance	C7 Rifle Range • Run-down drills Jungle Lane	Pugil Fighting Exit Questionnaires Exit Focus Group Kit Inspection
Supper				
PM		Night Patrol • 3 Fighting Patrols		

Table 1: Trial Schedule

2.2 Visor Conditions

This trial investigated four visor types across the following two visor conditions (see Figure 2 next page). Additional visor descriptions and sketches are provided in Annex A.

a) Ballistic Protection (V_{50}): Two levels of ballistic protection – Low (220 m/s) and Medium (450 m/s). The protection values indicated for these visors (i.e. V_{50}) is based on a industry standard for judging the ballistic protective capability of clothing and equipment. V_{50} refers to the striking velocity, of a specific projectile, at which 50% of the impacts achieve complete penetration.

b) Visor Shape: Two visor shapes – flat and curved.

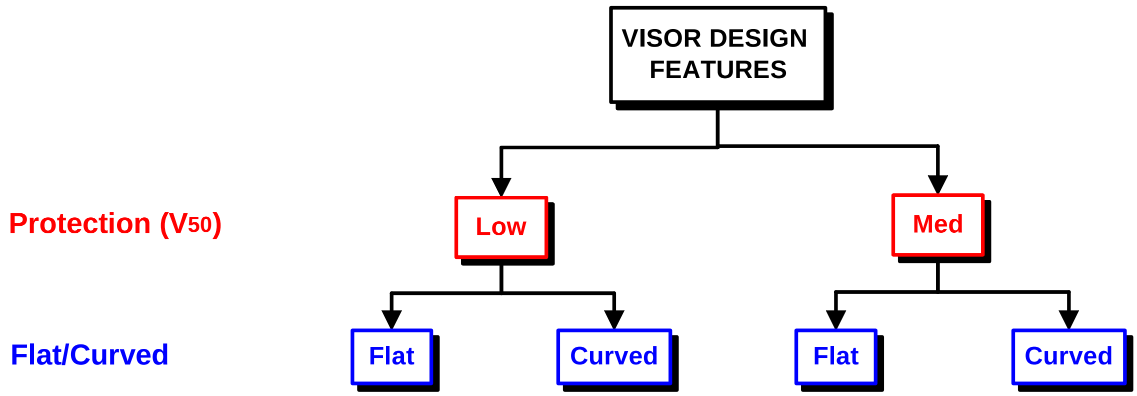


Figure 2: Visor Conditions

2.3 Progressive Testing Protocol

A progressive testing protocol was employed in this trial. Progressive testing starts by evaluating discrete, empirical variables which are likely to be involved in shaping soldier acceptance and performance in subsequent military activities and battle task drills. By measuring the effect of visor design differences on these discrete empirical variables in a highly controlled setting, it is possible to relate any differences in visor effects to observed or reported military performance and acceptance outcomes. Conversely, it is then possible to relate these outcomes back to the specific design characteristics responsible for any differences and to ameliorate any unwanted effects by providing directed visor design guidance.

The framework for progressive testing in this visor trial is outlined in Figure 3. Having already selected participants for V1 vision, which is the highest vision standard in the Canadian Forces, Stage 1 began with empirical clinical tests to determine the discrete visor design effects on two fundamental visual performance variables: visual discrimination (acuity) and depth perception. These variables were tracked throughout the remaining field trial testing.

Stage 2 built on Stage 1 by introducing static test stands that incorporated military or infantry domain relevance. These stands included compatibility tests to assess weapon and equipment compatibility with each of the visor designs. Any identified incompatibility or clash was further assessed to determine if the participant could overcome the clash through helmet and visor adjustment and to determine the extent to which soldier performance was affected. Finally, an Observation Post (OP) surveillance test was undertaken to assess the effect of visor design on target detection and recognition throughout the field of view, in a static field environment.

Stage 1:
Clinical Tests

- **FOV Test**
- **FOV Acuity Test**
- **Stereo Acuity Test**

Stage 2:
Static Military Tests

- **OP Surveillance**
- **Weapons Compatibility**
- **Equipment Compatibility**

Stage 3:
Dynamic Discrete Military Activities

- **Obstacle Course**
- **C7 Rifle Range**
- **Driving Test**
- **Jungle Lane**

Stage 4:
Dynamic Military Battle Tasks

- **Night Patrol**
- **FIBUA Fighting**
- **Pugil Fighting**

Figure 3: Progressive Testing Protocol

Stage 3 built again on Stage 2 by adding tests that incorporated dynamic movement and discrete military activities. The obstacle course assessed the stability and load force effects of the visor designs during typical field movements and obstacle traversing maneuvers with the head oriented in a wide range of postures. The run-down drills during C7 range firing built on previous static test stands for rifle compatibility and targeting by adding rapid movement, the complete range of firing postures, limited time to acquire and engage the targets, and range scoring. The jungle lane test introduced additional realism by requiring participants to advance down a wooded trail, detect soldier targets presented in their peripheral visual field, and engage those targets with their personal weapon.

Finally, Stage 4 built on all previous stages through the performance of infantry battle tasks, which combine many infantry activities and skills into high fidelity simulations of combat missions. Night patrolling assessed visual demands of patrolling and contact engagements with an enemy force, with the added effects of glare and reduced ambient illumination and contrast. Given the importance that the DLR concept of operations assigns to the use of a visor in FIBUA warfare, a section-on-section assault was simulated in a FIBUA village using paint-ball weapons in a capture-the-flag scenario.

At the completion of all four stages of testing, participants were required to rate the effectiveness and characteristics of each visor design and to discuss the rationale for their opinions in an Exit focus group discussion.

2.4 Trial Participants

Twenty regular forces infantry soldiers, with V1 vision, were provided for the duration of the trial. The participants were organized into two Sections (e.g. Sections A and B), each with 10 soldiers. Two senior NCOs were required to act as Section Comd throughout the trial; the senior NCOs were not participants in the trial, therefore 18 soldiers participated in the trial, 9 in each group. Each Section was balanced for visor size, so that each Section was as similar as possible (i.e. matched groups). An HF observer was assigned to work with each Section for the purposes of data collection and focus group discussions.

Using a Power analysis ($p \leq 0.05$), based on data from previous HF trials, a minimum of 9 participants were required for the repeated measures tests. Therefore, the planned sample size of 18 participants proved more than adequate for identifying any visor differences and given the need to drop to 10 participants for some tests which is described subsequently.

2.4.1 Visor Size

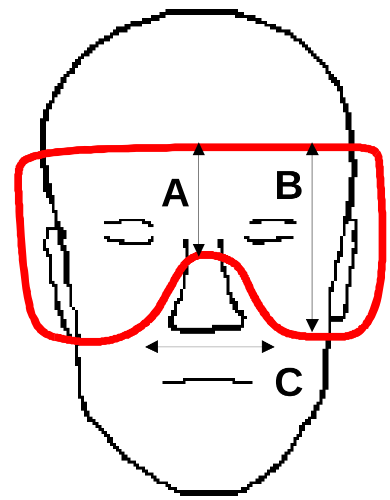
The prototype visors were sized to match the helmet sizes for the new CF Soldiers Helmet. Based on the results of the earlier VASS/Visor trial (reference A) and the low proportion of small head sizes in the infantry, visor sizes were restricted to the medium and large helmet sizes only for the purposes of this trial. As a result, prototype visors were produced for this trial in the following helmet size proportions (Table 2).

	Helmet Size		
	Small	**Medium**	**Large**
Head Circumference	51 - 55 cm	55 - 59 cm	59 - 62 cm
Overall Tariff % (n)	0% (0)	67% (24)	33% (12)

Table 2: Helmet Sizing and Trial Tariffing

Development of the initial visor design dimensions first required the determination of critical facial anthropometric dimensions. These dimensions characterized the projection of the nose in relation to the Soldier's helmet. Using 3D laser-scanned images of soldier's heads while wearing the appropriately sized helmet, DRDC identified the relative locations of the sellion (top of the nose) and pronasale (tip of the nose) landmarks for 30 representative soldiers in each of the small, medium, and large helmet sizes. These data were provided to Humansystems for further analyses.

For each helmet size, the populations of these landmark dimensions were displayed graphically, confidence ellipses established, and related to helmet landmarks. These data were combined to establish graphical profiles of the nose and helmet brim dimensions. Using this profile, the visor length to the bridge of the nose (A) and the overall length of the visor (B) were determined for each helmet size.



The width of the nasal cutout (C) was estimated using the anthropometric data for nose breadth from the 1988 Anthropometric Survey of U.S. Army Personnel (reference D) (note: the Canadian Land Force Survey (reference E) did not include this dimension).

Table 3 outlines both the initial and the prototype visor dimensions used for the field trial.

Visor Size	Visor Measure	Initial Dimensions	Prototype Dimensions
Small	A	5.0 cm	
	B	9.0 cm	
	C	5.0 cm	
Medium	A	6.0 cm	5.0 cm
	B	9.5 cm	9.5 cm
	C	5.0 cm	6.0 cm
Large	A	7.0 cm	6.0 cm
	B	10.0 cm	10.0 cm
	C	5.0 cm	6.0 cm

Table 3: Visor Dimensions

As can be seen in Table 3, the manufacturer chose to increase the allowance for the nasal cutout, to accommodate the thickness of the visor material, by reducing dimension "A" by 1.0 cm and enlarging dimension "C" by 1.0 cm.

2.5 Data

Data collection focussed on the following HF criteria. Test content is described in more detail below. The order of testing across the four visor conditions was balanced.

1. Anthropometry
2. Clinical Testing
3. Weapons/Equip. Compatibility
4. Features
5. Activity Performance
6. Battle Task Performance
7. Vehicle Compatibility
8. User Maintainability
9. Acceptance

2.5.1 Anthropometry:

Each participant was measured for a variety of anthropometric dimensions to enable the trial participant sample to be related to the Land Forces population and to assess the fit and shape of the prototype visor design in relation to facial landmarks.

Measured dimensions included head circumference, head length, head breadth, face length, bizygomatic breadth, and inter-pupillary distance.

2.5.2 Clinical Testing:

For each of the visor and no visor conditions, participants were required to complete a series of clinical tests designed to determine the discrete visor effects on visual performance.

a) Visual Acuity: Visual acuity was measured at two locations relative to the central line of sight. FOV1 was straight-ahead (i.e. 0^o deviation from the central line of sight). FOV2 was an angular deviation of 55^o from FOV1. FOV locations were achieved by positioning the participant's head relative to the computer display. The acuity test comprised computer-generated images of Landolt Rings of different sizes; the participant was required to verbally indicate the orientation of the gap in the rings. Background contrast and letter brightness were varied to simulate daylight and dusk conditions.

b) Stereoacuity: Stereoacuity was measured using the Frisby Stereo Test to determine visor effects on depth perception. Frisby targets were presented to the participant in two locations: straight ahead and at an offset angle ($\sim 55^o$) to one side of the visor.

c) Rifle Targeting: A rifle targeting test was employed to determine the extent of any prismatic or refractive deviations during visor use, and any associated effect on targeting accuracy. A target range was set-up in a drill hall with a targeting grid mounted on a Figure 11 target frame; the target grid and center of mass was indicated in white against the black background of the Figure 11. A prone fire position was set up at a distance of 25m from the Figure 11 target. The DCIEM bore-sighted laser pointer was mounted to the C7A1 rifle and activated by a rifle trigger switch. HF observers recorded the Cartesian deviation of the laser from the center of mass.

2.5.3 Weapons/Equipment Compatibility:

Visor compatibility clash was identified and evaluated at static test stands as part of a larger rotation scheme at the obstacle course. By including compatibility stands in the obstacle course rotation, the fatigue effects of the obstacle course were greatly reduced.

Participants performed the required compatibility drills and HF observers collected compatibility measurement data and participant ratings. Participants were encouraged to adjust and configure their helmets to the best of their ability to accommodate the test equipment prior to each test. Each participant was evaluated separately under the close observation of the HF observer, who noted instances of compatibility clash and the accommodation required to perform each drill. All tests were performed first in the helmet alone or no-visor control condition. Once participants completed a test stand they rotated to the next available stand.

The following compatibility test items were evaluated.

- C7A1 Rifle
- C9A1 LMG
- M72
- Carl Gustav
- Ballistic Spectacle
- Sand/Wind/Dust Goggle

2.5.4 Features

At the completion of the trial, participants were required to rate the suitability of select, prototype Visor features: securements, frames, etc. These features were discussed in detail during the exit focus group to identify feature concerns and suggestions for improvement.

2.5.5 Activity Performance

Visor effects on the performance of military tasks were evaluated for select combat activities (obstacle course, firing range, OP surveillance, jungle lane, pugil fighting). Participant performance data and ratings, and HF observer assessments were collected during each task. Tasks were performed in all visor conditions where possible.

a) Obstacle Course: The following combat activities were undertaken consecutively as part of a single course. At the completion of the obstacle course for each visor condition, participants completed a Task Questionnaire. Participants wore their webbing and carried their personal weapon.

The following obstacles were used:

100m Dash: Run 100m.

Ladder Obstacle: Ascend a 10m ladder, straddle and traverse the top bar, then descend the ladder to the ground.

Crawl: Perform a Leopard crawl for 10m under a low wire obstacle.

Irish Stones: Leap one-footed from stone to stone to cross a sandpit.

Wall Obstacle: Run 3m and climb over three low walls.

Pit Obstacle: Run up a 2m ramp and jump down into a sandpit and perform a forward roll.

Balance Beam: Walk along a zigzag balance beam mounted 0.5 m above the ground.

Over and Under Obstacle: Climb over and under three successive poles mounted 0.5 and 1.0 meter from the ground.

Mouse Hole Obstacle: Crawl through a square, concrete mouse hole shaft for 1m and climb over and under three successive poles mounted 0.5m, 1.0m, and 0.5m above the ground.

b) Range Firing: Using a small arms range, participants performed the following modified personal weapons test serials with the C7A1 rifle.

Serial 1: Grouping and zeroing at 100m (prone).

Serial 2: Fire and Movement starting in the prone position at 400m.
a) Double to 300m (prone unsupported, two Figure 11 targets).
b) Double to 200m (kneeling supported, two Figure 11 targets).
c) Double to 100m (prone unsupported, two Figure 12 targets).
d) Walk to 50m (standing, snapshooting, one Figure 11 target).

Participant performance was evaluated using standard target range scoring. Participants were required to rate the firing performance, stability, and comfort of each condition. At the completion of range firing, participants completed a Task Questionnaire for each condition.

c) OP Surveillance: For all visor and no visor conditions, participants were required to detect and recognize 3D Figure 11 targets in the wood line. Presentation of 3D Figure 11 targets was performed using the Static Infantry Target (SIT) system.

Test participants were positioned about 50 – 80 m from an encircling wood line, with their vision blocked, and wearing ear plugs to prevent aural target detection. Eight 3D Figure 11 targets, positioned at set angles (22^{o} intervals from the horizontal periphery) in the participant's visual field, remained hidden from view until electronically triggered. Once triggered, the SIT swung up into a "standing" position at the edge of the wood line. The participant's vision was unblocked and they were timed to detection of the soldier target. An HF observer recorded the time to detect the target and the participant's acceptance rating.

d) Jungle Lane: The jungle lane test comprised a trail bounded on either side by a line of dense bush. Participants were required to advance down the trail, detect and fire upon Static Infantry Targets (SIT). The participant wore earplugs to prevent aural detection. The HF observer accompanied the participant and electronically triggered the presentation of the SIT 3D Figure 11 targets. Upon detection, the participant engaged the target with blanks using their C7A1 rifle. The HF observers recorded the time from target presentation to first round fired as a measure of target detection and initial engagement. The HF observer recorded an overall acceptance rating at the completion of each jungle lane test.

e) Pugil Fighting: Participants engaged in pugil fighting to simulate crowd control conditions (i.e. defensive and offensive head and body movements, blows to the head, vision demands of close-in fighting, etc.).

2.5.6 Battle Task Performance

Visor effects on the performance of military battle tasks were evaluated for FIBUA warfare, and night patrolling. Participant performance data and ratings, and HF observer assessments were collected following each task. Tasks were performed in all visor conditions where possible.

a) Paint-Ball Capture-the-Flag: Participants were required to engage in FIBUA warfare simulation. Participants rated the effectiveness of all visor conditions. HF observers evaluated the speed, agility, task effectiveness, and visual performance effects in each visor condition.

One Section occupied the flag home base at the start of each game (defenders). The flag home base was situated behind the concrete bunker in the training area north of the new FIBUA site. The other Section (attackers) advanced 100m using Section fire and movement tactics through a wooded area and along two possible tracks, which converged on the concrete bunker. The attackers were required to fight up to and around the bunker building to capture the flag. Both sections were issued paint-ball weapons and ammunition, pyrotechnics (i.e. smoke and thunderflashes), and participants were issued disposable coveralls to protect their clothing.

Game play ceased when the attacking Section captured the flag or at the end of 45 minutes of play. At the completion of each game, participants completed a Task Questionnaire for the visor condition tested. The order of conditions was balanced within each Section. At the completion of each game, participants exchanged visors and setup for the next game.

b) Fighting Patrols (Night): Participants were required to perform three night patrols. One Section tested the two thin visors (i.e. flat and curved) and the other Section tested the two thick visors. All participants also performed a no-visor baseline patrol. Participants rated their effectiveness in all visor conditions. HF observers evaluated glare, adaptation, and night vision performance effects.

Each Section performed a stealthy patrol along the track used in the Area A Jungle Lane where they were “bumped” by an ambushing enemy force. The ambushing enemy force comprised SIT target systems and Light Hostile Fire Simulators (LHFS). Each ambush was observed by an HF observer. Glare sources (e.g. flares, vehicle headlights) were also introduced during the patrol.

Once bumped the Section performed standard skirmishing fire and movement tactics to suppress, advance, and assault the enemy position. Participants were issued blank ammunition. At the completion of each engagement, participants completed a Task Questionnaire to rate each visor condition. The order of conditions was balanced within each Section. At the completion of the patrol, participants exchanged visors and repeated the drill.

2.5.7 Vehicle Compatibility

All visor conditions were evaluated for compatibility with the Grizzly Armoured Vehicle, General Purpose (AVGP). Order of conditions were balanced. Specific evaluations included:

a) **Vehicle Operation:** Participant driving performance was evaluated using a forward slalom course. Participants were required to drive a course bounded by flag posted markers positioned at each of the corners of the course. Participants were required to rate their performance in vehicle operation in each visor condition in a Task Questionnaire. HF observers evaluated participants during vehicle operation for any postural, range of movement, crewstation obstruction, and vision effects, and noted driving accuracy in terms of the number of slalom course markers hit by the vehicle.

2.5.8 User Maintainability/Durability:

The ease and effectiveness with which a participant could effect minor visor repairs and cleaning in the field was evaluated through maintenance simulations, focus group discussion, and questionnaire ratings. HF observers observed maintenance tasks as they occurred in the field. All damage and repairs were logged and reviewed for durability issues. Suitability for field cleaning was evaluated in the field as appropriate. All prototype visors were inspected for wear and damage at the completion of the trial.

2.5.9 User Acceptance:

To assess user acceptance, participants were required to rate their overall acceptance of each visor condition, including their perceived level of protection, and ease of use, general appearance, durability and functionality, using the exit questionnaire.

2.6 Statistical Analyses

A repeated-measures analysis of variance, for visor effect, was undertaken for all questionnaire acceptability scale and performance results. Ranking data in the exit questionnaire was analyzed using a non-parametric Friedman two-way analysis of variance. Differences are identified at $p \leq 0.05$.

3. RESULTS

Trial results are detailed in the following Annexes and summarized below.

Annex A	Visor System Descriptions
Annex B	Participant Characteristics
Annex C	Clinical Evaluations
Annex D	Equipment and Weapon Compatibility
Annex E	Task Performance
Annex F	Vehicle Compatibility
Annex G	Exit Focus Group

3.1 Visor System Descriptions (Annex A)

See Annex A for a description of the trial visor conditions.

3.2 Participant Characteristics (Annex B)

The participant sample of male soldiers employed in this trial was representative of the larger population of Land Force males, with the exception of a somewhat narrower average interpupillary distance. One can only speculate on the impact of a somewhat narrower interpupillary distance. Weapon sight compatibility might be somewhat worse since the soldiers would need to position their heads somewhat closer to the rifle butt. The location of field of view obstruction for the corners of the flat visor would also have been less directly in the central field of view. In other words, some compatibility issues might have been made worse and some of the central field of view aspects might have been improved somewhat.

3.3 Clinical Evaluations (Annex C)

Visor wear clearly reduced visual performance from baseline (no visor) levels, as evidenced by a statistically significant and practically noticeable reduction of visual acuity. This loss in visual performance was more marked when viewing from the sides of the visor than straight-ahead. The thickness or the shape of the visors, however, did not affect these losses in visual performance. Several participants did indicate having difficulty performing the offset angle viewing (55^o) with the flat visors due to the field of view obstructions at the 90^o bends from the front to the sides.

No stereoacuity differences were identified between the baseline (no visor) and visor conditions, and there were no differences between visor types for straight-ahead viewing. This suggests that the loss in normal acuity did not affect depth perception.

Tests on the prismatic and refractory effects of visor wear, when used to target the C7A1 rifle with the C79 sight, did not reveal any visor effects when compared to the baseline (no visor) condition.

3.4 Equipment and Weapon Compatibility (Annex D)

Weapon and equipment compatibility testing revealed several concerns with respect to clash and performance decrements associated with visor use.

3.4.1 Weapon Compatibility:

Rifle compatibility is affected by the stand off between the eye and the C79 sight, imposed by any visor, and the ability of a soldier to obtain a proper sight picture. To acquire a complete sight picture, participants were required to position the nasal cut-out of the visor on to the top of the rifle butt. Rifle compatibility problems stemmed from additional time required to position the nasal cut-out.

The C9 LMG was affected the least by this impediment as C9 gunners usually only use the sight for the first burst and then look over the sight to see tracer or the fall of shot to adjust their point of aim for subsequent bursts. The requirement to position the nasal cutout is therefore reduced on subsequent bursts. The ability to see over the weapon and adjust the point of aim was not impeded by the visors.

C7A1 compatibility with visors was significantly less acceptable than the C9A1. Rifle compatibility problems stemmed from additional time required to position the visor nasal cutout and, for the flat visors, the reflected glare was distracting.

With the visor in the down position, participants were also unable to acquire a sight picture with the Carl Gustav SRAAW; no problems acquiring a sight picture were reported with the visor in the up position.

M72 compatibility was acceptable, although less so for the flat visors due to reflected glare. Participants were also able to achieve the correct firing posture with both thick and thin visors.

3.4.2 Equipment Compatibility:

While no clash concerns were identified for ballistic eyewear or the Sand/Wind/Dust (SWD) goggles, some participants noted the potential for the eyewear to exacerbate visual distortion problems with the thick visors, particularly if the eyewear was scratched or dirty.

3.5 Task Performance (Annex E)

The results of the military and battle task tests is summarized below and detailed in Annex E.

3.5.1 Obstacle Course:

Overall, the visor ratings were significantly less favourable than the no visor condition. With the exception of the Curved Thin visor, participants reported that the bulk, weight and balance of the visors (particularly the thick visors) impeded their performance on the obstacle course. Only the Curved Thin visor was rated as generally acceptable.

3.5.2 Range Firing:

The participants generally rated the visors as unacceptable for rifle firing. While thin visors tended to be rated more favourably than thick visors for load effects and visual performance, only the Curved Thin visor achieved "barely acceptable" ratings for factors affecting load force effects on the head and neck. The results from the range firing, however, revealed that range firing performance was not affected by visor wear. This apparent anomaly can be explained by the participant's ability to overcome the compatibility limitations of the visors during rifle firing. To achieve a good sight picture, participants needed to position the nose cutout of the visor over the ridge of the butt of the weapon and then move their heads into correct position within the helmet. Participants reported that they had sufficient time on the range to reposition the head and visor, although concerns were raised regarding any delay in sighting a weapon during actual combat.

3.5.3 OP Surveillance:

Generally, thin visors were rated as acceptable and were preferred to thick visors, which were typically rated as unacceptable. The Curved Thin visor was rated significantly more favourably than the other visor conditions for field of view, target detection to the sides, and glare/haze. There were no performance differences in the time to detect targets between the no visor baseline and the visor conditions, and no difference between visors.

3.5.4 Jungle Lane:

With the exception of the Curved Thick visor, the remaining visors were reported as acceptable for jungle lane firing. The curved thick visor was reported as causing depth perception and visual distortion problems as well as inducing feelings of nausea in some participants. The nausea effects were most pronounced during the target acquisition phase of the jungle lane task. There were no performance differences in the time to detect and engage targets between the no visor baseline and the visor conditions, and no difference between visors.

3.5.5 Pugil Fighting:

The participants unanimously agreed that the visors were unacceptable for use during pugil fighting or related tasks. Generally, there were no significant differences between visor conditions. Visors were rated as unacceptable, with the exception of the Curved Thin visor for balance, range of head movement, speed of head movement, and nausea.

3.5.6 PaintBall/Capture-the-Flag:

The thin visors were generally rated as acceptable and significantly more favourably than the thick visors (typically rated as unacceptable).

3.5.7 Night Patrol:

The participants reported that the visors were unacceptable for use on night patrols. With the exception of thin visors being favoured over thick visor for balance, there were no appreciable differences between visor conditions.

3.6 Vehicle Compatibility (Annex F)

Overall, the visors assessed in this trial were preferred over the no-visor condition for ballistic and sand/wind/dust protection and were generally rated as suitable for driving tasks.

The thin visors, both flat and curved, were similarly rated as acceptable for all features assessed and were typically rated more favourably for most features than both the thick curved and flat visors. The flat and curved thick visors did not fair as well. Since driving is predominantly a visual task, when driving with the hatches up, anything that detracts from a driver's visual performance will be problematic. This was the case with the thick visor systems studied.

Participants expressed dissatisfaction with the thick visors due to reduced visual performance associated with glare/haze, distortion and reduced depth perception. The curved thick visor was considered worse than the flat thick visor for these visual deficiencies. The thick visors, while affording greater ballistic protection than the thin visors, were also heavier and bulkier. The increased load forces of the thick visors during vehicle movement was cited as contributing to neck fatigue and discomfort, likely leading to reduced driver attention and performance during prolonged driving activities.

3.7 Exit Focus Group (Annex G)

The following section summarizes the results of the Exit focus group discussions and questionnaires.

3.7.1 Criteria of Importance:

Overall, participants rated weapons compatibility as the most important feature of any general purpose visor. The next most important criteria included:

- visual performance (i.e. depth perception, visual distortion, field of view, eye fatigue, and visual sharpness);
- target detection (i.e. target detection to the front and sides);
- ventilation/fogging, thermal load, glare/haze;
- detectability by the enemy; and
- Battle task performance (i.e. Section attack, FIBUA, night patrol, obstacle traverse).

Participants rated the following criteria as having the lowest importance:

- visor stowage;
- appearance;
- eyewear and clothing compatibility; and
- minor repairs.

3.7.2 Visor Features:

For all visor conditions the attachment connection between the visor and the visor attachment sub-system, secured to the helmet, proved problematic. The visor connector was comprised of a male Fastex-type connector that mated with the female slots in the visor attachment sub-system. All visors were rated poorly for the durability of the stabilizer post and the male connector. The stabilizer post broke easily during trial testing, which then allowed the visor to move independently of the helmet. Many participants rated the male connector poorly for durability due to perceptions about the "plastic" materials used and the associated lack of robustness in prolonged use and in winter temperatures.

While the nasal cutout of the visor was generally rated as "borderline to barely acceptable", many participants suggested that the cutout should be larger to allow for more ventilation to reduce the likelihood of fogging. The use of the white gasket or spacer around the periphery of the thick visors, between the two layers of polycarbonate, proved to be a visual distraction for participants.

The hinges used in the flat visors were seen as functionally unacceptable and a concern for durability. Most participants indicated that the hinges did not enable the folded visor sides to lie flat and, as a result, the visor remained somewhat bulky for stowage.

3.7.3 Exit Questionnaire:

Visors were generally rated as unacceptable for:

- Rifle and Shoulder-fired Weapons Compatibility;
- Stowage (Flat Thin was Borderline);
- Ventilation/Fogging and Thermal Load;
- Durability, Cleaning, and Minor Repairs;
- Blunt Trauma Protection;
- Glare/Haze, Appearance, Detectability; and
- Obstacle Traverse, FIBUA (outside), and Section Attacks.

Thin visors were rated more favourably than Thick visors for:

- Attachment and Adjustment;
- Visual Sharpness and Distortion;
- Physical forces and Comfort; and
- Vehicle Driving.

The Curved Thin visor was rated significantly more favourably than other visors for:

- FOV and Target Detection (sides);
- Glare/Haze; and
- Appearance.

Overall, the Curved Thin visor was rated significantly more favourably than all other visors and was the only visor considered acceptable. During focus group discussions, most participants (78%) preferred the Curved Thin visor over the Flat Thin visor (only 22%). The Curved Thick visor proved to be the most disliked visor (83%) due to the resulting loss of visual performance.

4. DISCUSSION

Prior to undertaking this field trial it was generally known that soldiers were resistant to the notion of wearing a general-purpose visor. Since soldiering tasks rely heavily on the visual sense, anything that might reduce a soldier's visual performance will typically be met with significant resistance or rejection. Even though there is ample evidence that injuries to the eyes and face are increasing, and often serious, with the greater use of fragmentation weapons in urban combat, the soldiers in this trial appeared reluctant to accept the need for facial and ocular protection. Since they did not appreciate the need for visor protection most participants preferred to focus on the associated impediment to vision. The challenge in this trial was to determine whether the trial participants would be willing to consider a general-purpose visor for military tasks.

To determine the opportunities, and limits to acceptance, for a general-purpose visor, four different visor designs (flat vs curved shapes in two levels (thicknesses) of protection) were developed and trialed in a wide range of representative infantry tasks with a range of in-service weapons and equipment.

4.1 Visor Acceptance

Soldiers indicated that the most important assessment criteria for a general-purpose visor were weapon compatibility and visual performance. The visor posed a number of concerns in these areas. Participants rated visor use with the C7A1 rifle as unacceptable due to the slight delay necessary to position the nasal cutout over the rifle butt to achieve a full sight picture. While annoying, participants quickly learned to adjust to the extra head movement needed during sighting to accommodate the visor. This is evidenced by the lack of any differences in range firing performance between the visors and the no visor baseline (participants were unaware of their range performance prior to rating the visors for weapon compatibility). Participants did, however, express concern about the time delay in real combat situations.

Visual performance was another concern among participants. Visual acuity tests confirmed that all of the visors tested produced a small but significant drop in visual performance. While participants did rate the visual performance aspects (e.g. visual sharpness, field of view, distortion, depth perception, etc.) of visors as low, there was generally a significant difference in acceptance between the thin and the thick visor designs. The thick visor designs (i.e. double layer of polycarbonate) were seen to produce a greater visual decrement than the thin, single layer designs. The curvature of the thick visor made any inherent visual distortion more pronounced than the flat design of the thick visor, resulting in a greater perceived loss of visual performance and, in some cases, feelings of nausea. Overall, the curved thick design was most disliked (83% of participants).

In addition to the visual performance differences between the thin and thick visors, participants also noted additional musculo-skeletal stress and fatigue at the neck associated with the higher load forces of the thick visors. These higher load effects were more pronounced during activities requiring quick head movements (e.g. obstacle course, Section attack) and reaction to external forces (e.g. vehicle driving). In most evaluations, the thick visors were rated as unacceptable.

Participants also evidenced considerable concern about the ease with which an enemy observer might detect a highly reflective visor. The curved visors always reflected a small amount of glare whereas the flat visor design produced more intermittent glare. The large surface area of the flat visor (i.e. flat plate) resulted in a much larger amount of reflected glare, which was more detectable by observers at a greater distance.

For the thin visors, the curved design was preferred (78% of participants) to the flat design (22%). For the flat design, the hinges used to improve the stowage footprint resulted in a field of view obstruction in the front corners of the visor. Most participants were unable to totally accommodate to these blindspots on the left and right sides of their visual field. The surface of the flat visor also introduced a noticeable amount of reflected glare into the participant's line of sight, creating a source of distraction and a further loss of visual performance. Although the flat design was developed to provide a compact form factor for stowage, participants saw the resulting loss of visual performance (i.e. field of view obstruction and glare) as an unacceptable trade off. This is further confirmed by the very low ratings of importance that participants assigned to stowage for selecting a visor. Participants also noted that the folding design did not achieve its intended small stowage profile. Overall, the curved thin visor was the only visor to be judged as generally acceptable for a general-purpose visor.

During the focus group discussion, participants indicated that the curved thin visor would be suitable for driving vehicles, riot control or reaction to a hostile crowd, fighting in built up areas, and occupying a defensive position. Most participants (72%) would be willing to accept a visor for conventional warfare tasks if the concept of operations allowed them to raise the visor into a fixed "up" position when not in a threat situation and when using certain weapons (e.g. Carl Gustav). All participants agreed that general acceptance of a visor would improve with experience.

4.2 Design Suggestions

During the Exit focus group discussion participants suggested the following modifications to the Curved Thin visor design.

1. Improve Compatibility: Chamfer the bottom rear corners of the visor (see Figure4) to enable a soldier to cheek their weapon without contacting the rifle butt with the corner of the visor. Any chamfering, however, should be considered with great care as it amounts to a loss of protection. At the very least, the amount of chamfering should be limited to the minimum amount necessary to achieve the required compatibility and no more. Though the lack of differences in range firing performance between the visor and no visor conditions indicate that chamfering may be an

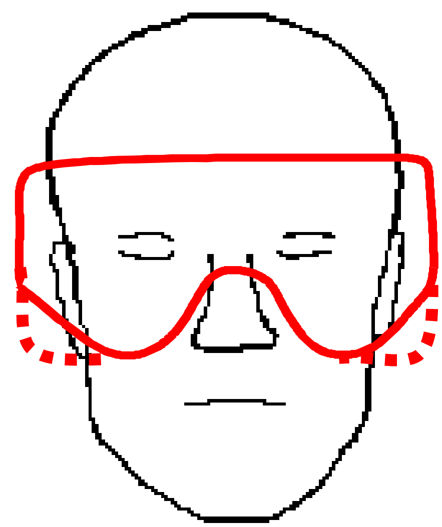


Figure 4: Chamfered Visor

unnecessary trade-off for loss of protection, it should be noted that range firing provides sufficient time to adapt to the compatibility clash.

2. Improve ventilation wherever possible. The nasal cutout could be enlarged to increase airflow under the visor. It is also likely that chamfering the bottom rear corners will further enhance airflow ventilation. As with chamfering, increasing the nasal cutout will also expose the wearer to more risk and should be undertaken with care. Anti-fogging treatments should be investigated as another means of mitigating any ventilation concerns.
3. Improve visual performance wherever possible by reducing the stress distortions associated with the shaping process used to curve the visor.
4. Investigate the most appropriate means of reducing the reflected glare detectability of the visor by the enemy. Various anti-glare treatments (e.g. coatings, etching) should be tested to determine the effects on glare reduction and the associated effects of visual performance.
5. Consider a family of visors. The Curved Thin visor design evaluated in this trial provided protective coverage to one-half to two-thirds of the face. This level of coverage was deemed acceptable by participants for high activity tasks typical of conventional warfare. However, many participants felt that a full-faced or oversized visor would be more suitable for riot control tasks or for exposed low activity tasks with a fragmentation threat (e.g. OP surveillance). Participants also noted the need for having a range of protective coatings (e.g. solar tinting, laser coatings, etc.). While a half-face visor was seen as acceptable for a general-purpose visor, most participants stressed the need for more special-to-purpose variants to meet the range of task demands and threats possible in today's medium and low intensity conflicts.
6. Visor attachment. Future field trials should be conducted to test the Visor Attachment System durability.

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ANNEX A – DESCRIPTIONS

1. Introduction

This trial investigated four visor types (Figures A-2 to A-5) for the following two visor criteria (see Figure A-1 below):

Ballistic Protection (V_{50}): Two levels of ballistic protection – Low (220 m/s) and Medium (450 m/s).

Visor Shape: Two visor shapes – flat and curved.

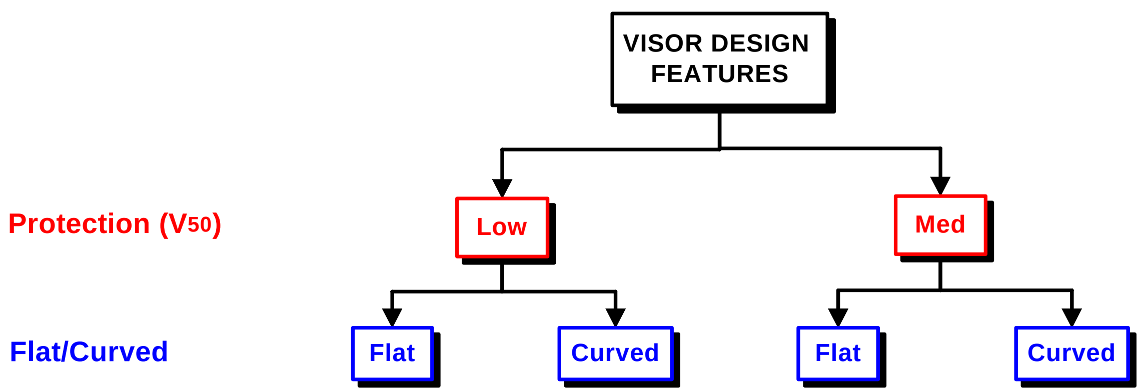


Figure A-1: Visor Conditions

These visor conditions (Figures 2 – 5) also differed across the following four dimensions (i.e. weight, thickness, shape, and field of view).

1. Weight varies directly in proportion to the level of protection (i.e. the 450 m/s visors are twice as heavy as the 220 m/s visors).

2. Two interactive vision conditions (visor thickness and shape) were included in a completely balanced 2x2 matrix for the following factors (i.e. both the flat and curved visors were provided in two thicknesses):

   Visor Thickness

   a) Thin (4 mm) for the 220 m/s visors.
   b) Thick (8 mm) for the 450 m/s visors.

Shape

a) Flat-faced visor with squared corners and a box-like shape.
b) Curved in one continuous bend (i.e. cylindrical).

3. Two levels of visual obstruction to the field of view:
   a) All single-piece, curved visors have no obstruction to the field of view.
   b) All flat visors were provided with a frame enclosure and hinges along the two front corners.

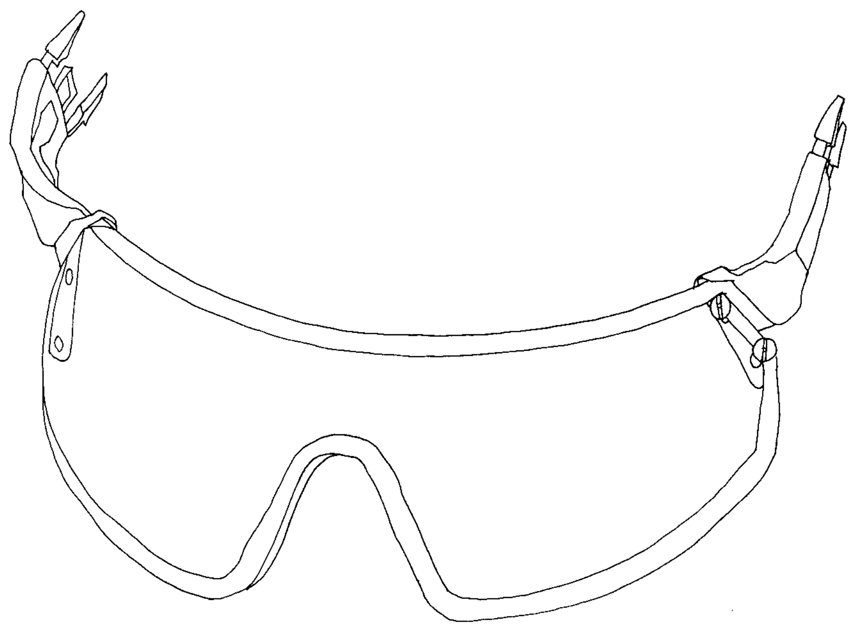


Figure A-2: Curved Thin Visor

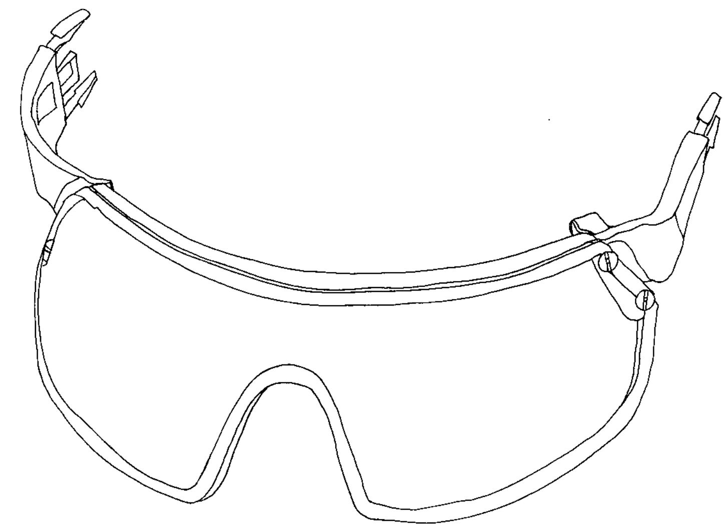


Figure A-3: Curved Thick Visor

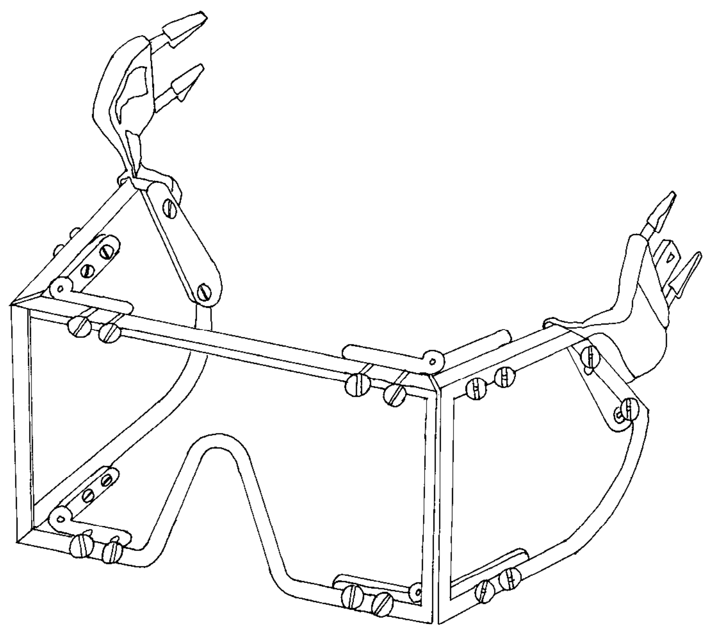


Figure A-4: Flat Thin Visor

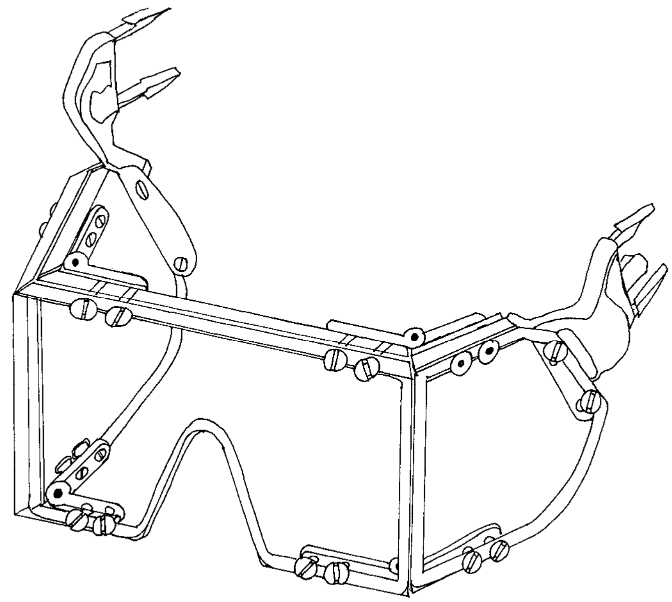


Figure A-5: Flat Thick Visor

ANNEX B – PARTICIPANTS ANTHROPOMETRIC HEAD DIMENSIONS

1. Introduction

Each participant was measured for a variety of anthropometric head dimensions for comparison of the trial participant sample to the 1997 Land Forces Survey (reference E) population and to assess the fit and shape of the prototype visor design in relation to facial landmarks.

2. Method

Participant dimensions included head circumference, head length, head breadth, face length, bizygomatic breadth, and inter-pupillary distance.

A Personal information questionnaire was also completed detailing the military and occupational experience of each participant, including operational deployments such as UN and NATO tours.

3. Results

Participants comprised 18 male soldiers (16 Pte and 2 Cpl). All participants were dismounted infantry serving with 1 Bn RCR. All participants were confirmed as V1 (for vision) at the start of the trial. Anthropometric data is summarized in table B-1 below.

	Participants			LF 97 Survey		
Measure	**N**	**Mean**	**s.d.**	**N**	**Mean**	**s.d.**
Head Circumference	18	57.2	1.5	466	57.6	1.5
Head Length	18	19.7	0.5	466	19.9	0.7
Head Breadth	18	15.2	0.4	466	15.3	0.5
Face Length	18	12.2	0.6	466	12.0	0.7
Bizygomatic Breadth	18	14.2	0.5	466	14.1	0.6
Interpupillary Distance	18	**5.7**	**0.5**	466	6.3	0.3

Table B-1: Anthropometric Data

The participant dimensions are similar to the Land Force 97 data with the exception of interpupillary distance, where the participant dimensions are smaller. These participant head dimensions were reflected in the helmet size distribution of 13 medium (72%) and 5 large (28%).

Army experience:

The participant sample reported the following length of service:

- 0 - 1 year = 61% (11)
- 1 - 5 years = 28% (5)
- 5 - 10 years = 11% (2)

Operational experience

Eleven percent (2 participants) reported at least one peacekeeping tour.

4. Discussion

The participant sample of male soldiers employed in this trial was indicative of the larger population of Land Force males, with the exception of a somewhat narrower average interpupillary distance. One can only speculate on the impact of a somewhat narrower interpupillary distance. Weapon sight compatibility might be somewhat worse since the soldiers would need to position their heads somewhat closer to the rifle butt. The location of field of view obstruction for the corners of the flat visor would also have been less directly in the central field of view. In other words, some compatibility issues might have been made worse and some of the central field of view aspects might have been improved somewhat.

ANNEX C – CLINICAL TESTING

1. Introduction

For each of the visor and no visor conditions, participants were required to complete a series of clinical tests designed to determine the discrete visor effects on visual performance: FOV acuity and stereoacuity. Each test was performed with the participant viewing the test through the front (i.e. straight ahead) and the side of the visor.

2. Method

2.1 Acuity: Visual acuity was measured at two FOV locations relative to the central line of sight by presenting images on two computer monitors. The acuity test comprised computer-generated images of Landolt Rings of different sizes where the participant was required to verbally indicate the orientation of the gap in the rings. The Landolt ring includes a gap, equal to the width of the ring, which can appear in any one of four positions (i.e. top, bottom, left or right). Visually acuity is based on the smallest gap size that the participant can resolve.

The luminance and contrast levels of the computer monitors were standardized with background luminance being 92-100 cd/m^2 and letter contrast being 7-10%. FOV locations were achieved by positioning the participant's head relative to the computer display. FOV1 was straight-ahead (i.e. 0^o deviation from the central line of sight). FOV2 was an angular deviation of 55^o from FOV1 (see Figure C-1 below).

Figure C-1: FOV Acuity Test Stand

2.2 Stereoacuity: Stereoacuity was measured using the Frisby Stereo Test to determine visor effects on depth perception. Participants were tested on their ability to visually discriminate a stereo image pattern among three glass plates of different thicknesses. The thickness of the plate corresponds to the level of stereo acuity (i.e. plate thickness of 1.5mm = 150 seconds of arc, 3.0mm = 300 second of arc, and 6.0mm = 600 seconds of arc). The thinner the plate used to detect the stereo pattern the better the participant's stereoacuity. Frisby targets were presented to the participant in two locations: straight ahead and at an offset angle (~55^{o}) to one side of the visor.

Figure C-2: Stereoacuity Test Stand

2.3 Rifle Targeting: A rifle targeting test was undertaken to determine the extent of any prismatic or refractive deviations caused by the visor, and any associated effect on targeting accuracy. A target range was set up in a drill hall with a targeting grid mounted on a Figure 11 target frame; the target grid and center of mass was indicated in white against the black background of the Figure 11 target. Soldiers adopted a prone fire position at a distance of 25m from the Figure 11 target (see Figure C-3 below). The DCIEM bore-sighted laser pointer was mounted to the C7A1 rifle and activated by a rifle trigger switch. Participants were required to sight on the target and pull the trigger when their reticle was "ON", thereby triggering the laser. The HF observer recorded the Cartesian deviation (i.e. x, y) of the laser from the center of mass.

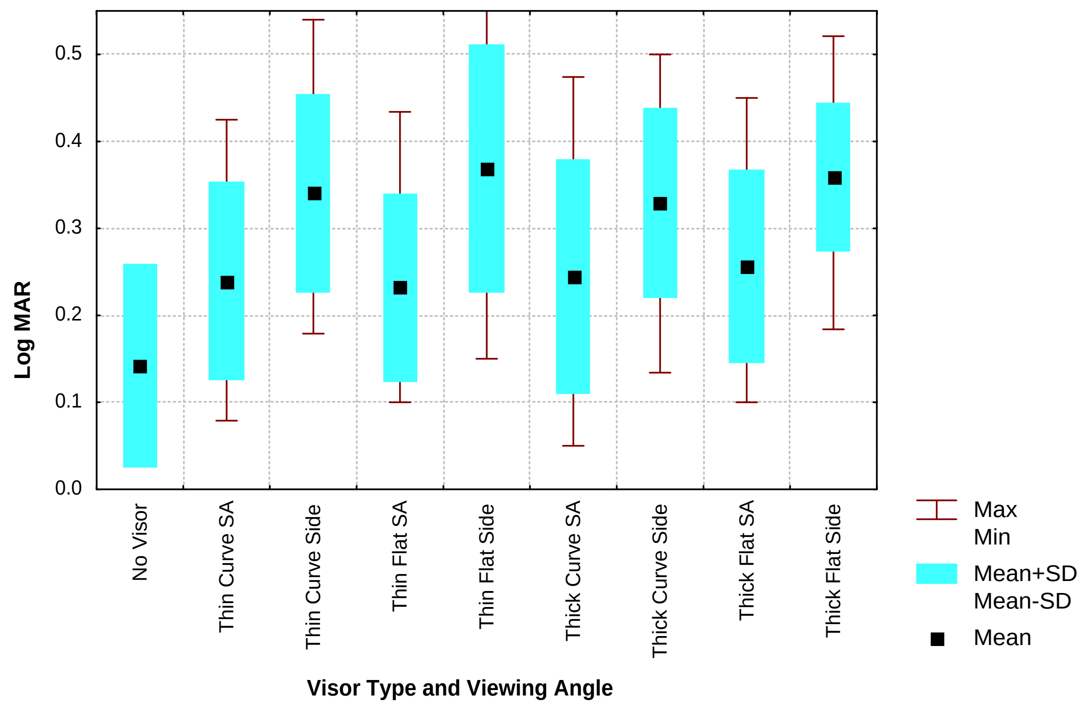
Figure C-3: Rifle Targetting

3. Results

3.1 FOV Acuity:

Descriptive acuity results are depicted in Figure C-4 in logMAR units for each of the baseline (no visor), and the straight ahead and 55^o offset angle viewing for each of the four visor types. The smallest gap resolvable by each participant is recorded by the arc subtended at the soldier's eye in minutes of arc, which is referred to here as the Minimum Angle of Resolution (MAR). Since basic visual functions are linear when depicted on a log scale, a logMAR scale is used. For the sake of reference, 0.0 logMAR corresponds to 20/20 (or 6/6) vision and 0.3 logMAR corresponds to 20/40 (or 6/12).

Given the use of low contrast letters in the test, the baseline acuity values are considered normal. For all visor conditions, visual acuity was reduced from baseline values ($p<.001$). Acuity values for viewing to the sides (i.e. 55^o offset angle) were significantly worse than values for straight ahead viewing ($p<.002$). There was no statistically significant difference between visor conditions.



Legend: SA = straight ahead, Side = 55° offset angle

Figure C-4: FOV Acuity

3.2 Stereoacuity:

Stereoacuity was unaffected by visor type when viewing the test plates in the “straight ahead” orientation (see Figure C-5). Due to the effective loss of one eye, stereoscopic viewing of the plates in the offset angle (55°) position was not possible.

3.3 Rifle Targeting:

No significant statistical differences were identified for the accuracy of rifle targeting between the baseline and the visor conditions. In fact, the margin of variation about the target center was very small across all conditions.

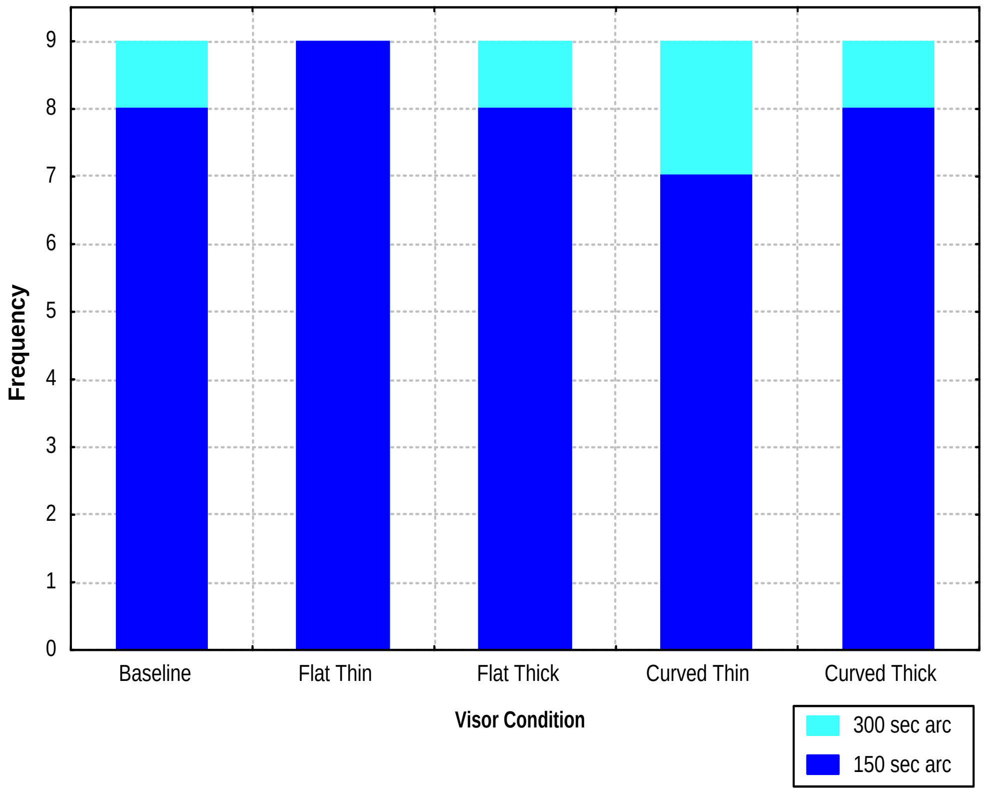


Figure C-5: StereoAcuity

4. Discussion

Visor wear clearly reduced visual performance from baseline (no visor) levels, as evidenced by a statistically significant and practically measurable reduction of visual acuity. This loss in visual performance was more marked when viewing from the sides of the visor than straight-ahead. The thickness or the shape of the visors, however, did not affect these losses in visual performance. Several participants did indicate having difficulty performing the offset angle viewing (55^{o}) with the flat visors due to the field of view obstructions at the 90^{o} bends from the front to the sides.

No stereoacuity differences were identified between the baseline (no visor) and visor conditions, and there were no statistically significant differences between visor types for straight-ahead viewing. This suggests that the loss in normal acuity did not affect depth discrimination.

Tests on the prismatic and refractory effects of visors were assessed during rifle targeting with the C79 sight. No significant visor effects were identified, when compared to the baseline condition.

ANNEX D - EQUIPMENT / WEAPON COMPATIBILITY

1. Introduction

Compatibility clash testing was undertaken to assess a soldier's ability to effectively operate personal weapons and wear protective eyewear equipment with the various visor conditions. Clash refers to the occurrence of an obstruction, between clothing and equipment items and the soldier, which may prevent items from being worn or used in the most ideal fashion. Depending on the extent and nature of the clash, the compatibility obstruction could result in reduced performance and comfort, which could ultimately diminish soldier effectiveness.

2. Method

Visor compatibility clash was identified and evaluated at static test stands as part of a larger rotation scheme at the obstacle course. Participants performed the required compatibility drills and HF observers collected compatibility measurement data and participant ratings. Participants were encouraged to adjust and configure their helmets to the best of their ability to accommodate the test equipment prior to each test. To assess the compatibility of personal weapons for each visor condition, participants were required to perform loading, unloading and misfire drills with typical weapon systems. Each participant was evaluated separately under the close observation of the HF observer, noting instances of compatibility clash and the accommodation required to perform each drill. All tests were performed first in the helmet alone or no-visor control condition. Once participants completed a test stand they rotated through each of the test stands.

The following compatibility test items were evaluated.

- C7A1 Rifle (Figure D-1)
- C9 LMG (Figure D-2)
- M72 (Figure D-3)
- Carl Gustav (Figure D-4)
- Ballistic Spectacle (e.g. Bolle or Uvex)
- Sand/Wind/Dust Goggle (Figure D-6)

Figure D-1: C7A1 Compatibility Testing

Figure D-2: C9 Compatibility Testing

Figure D-3: M72 Compatibility Test Stand

Figure D-4: Carl Gustav Compatibility Test Stand

3. Results

Results are summarized below for weapon compatibility and for equipment compatibility.

3.1 Weapon Compatibility:

Weapon compatibility was evaluated for both personal weapons (i.e. C7A1 and C9 LMG) and short range anti-armour weapons (i.e. M72 and Carl Gustav).

3.1.1 C7A1 and C9 LMG

Summary results for visor type compatibility with the C7A1 and C9 LMG are depicted in Figure D-5 below.

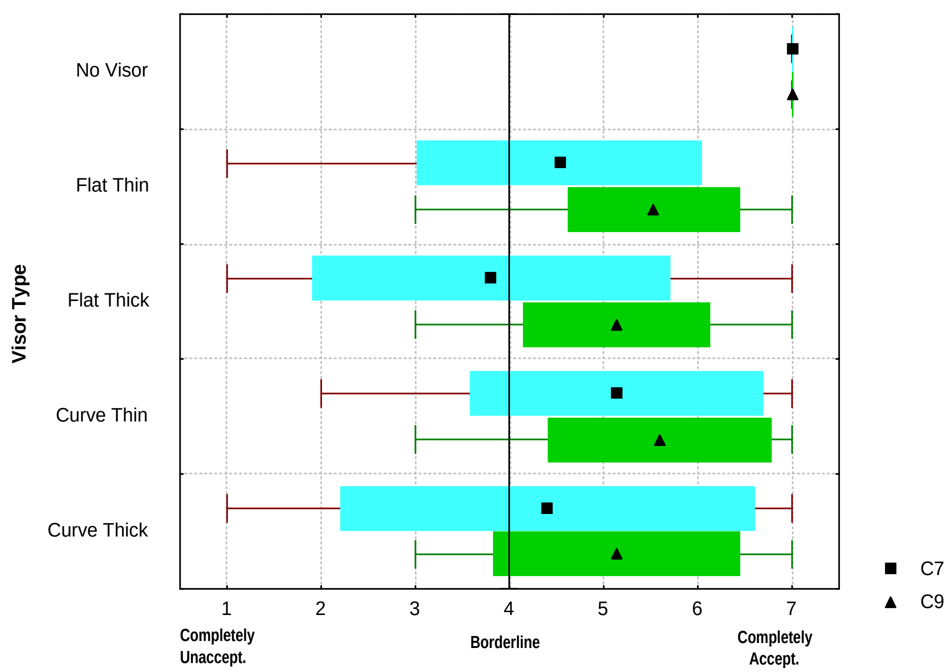


Figure D-5: C7 and C9 Compatibility

C7A1 compatibility with visors in general was significantly less acceptable than the C9 LMG. Overall, the mean C7A1 ratings were borderline to barely acceptable, with only the flat thick visor being rated as unacceptable. To acquire a complete sight picture, participants were required to position the nasal cut-out of the visor on to the top of the rifle butt. Visor compatibility problems with sighting the rifle stemmed from the additional time required to position the nasal cut-out of the visor over the rifle butt. Soldier requirements for sighting the C9 LMG were not as demanding and accounted for the higher mean ratings between barely and reasonably acceptable. For both weapons, participants commented on the visual distraction resulting from reflected glare with the flat visors during sighting.

3.1.2 Carl Gustav and M72 Compatibility:

Participants reported that it was extremely difficult use of the Carl Gustav with any visor in the down position. Their inability to acquire a sight picture was noted as the primary reason for the negative ratings (see Figure D-4). Used in the "up" or stowed position, the visors did not present difficulties when performing the firing drills with the weapon.

M72 compatibility was reported as acceptable for all visor conditions. Participants noted, however, that significant time delays were required in order to position the nasal cut-out of the visor satisfactorily on the weapon to acquire a sight picture (see Figure D-3). Curved visors were preferred over the flat visors since the flat visors introduced distracting reflected glare during sighting.

3.2 Equipment Compatibility:

Participants did not identify any clash concerns for ballistic eyewear or the Sand/Wind/Dust (SWD) goggles (Figure D-6). Some participants noted the potential for exacerbating visual distortion problems with the curved thick visor.

Figure D-6: Sand/Wind/Dust Goggle Compatibility

4. Discussion

Weapon and equipment compatibility testing revealed several concerns with respect to clash and performance decrements associated with visor use.

Weapon Compatibility:

Rifle compatibility is affected by the stand off between the eye and the C79 sight, imposed by any visor, and the ability of a soldier to obtain a proper sight picture. To acquire a complete sight picture, participants were required to position the nasal cut-out of the visor on to the top of the rifle butt. Visor compatibility problems with the rifle stemmed from the additional time required to position the nasal cut-out.

The C9 LMG was affected the least by this impediment as C9 gunners usually only use the sight for the first burst and then look over the sight to see tracer or the fall of shot to adjust their point of aim for subsequent bursts. The requirement to position the nasal cutout is therefore reduced on subsequent bursts. The ability to see over the weapon and adjust the point of aim was not impeded by the visors.

C7A1 compatibility with visors was significantly less acceptable than the C9 LMG. Rifle compatibility problems stemmed from additional time required to position visor nasal cut-out and, for the flat visors, the reflected glare was distracting.

With the visor in the down position, participants were also unable to acquire a sight picture with the Carl Gustav SRAAW; no problems acquiring a sight picture were reported with the visor in the up position.

M72 compatibility was acceptable, although less so for the flat visors due to reflected glare. Participants were also able to achieve the correct firing posture with both thick and thin visors.

Equipment Compatibility:

While no clash concerns were identified for ballistic eyewear or the SWD goggles, some participants noted the potential for exacerbating visual distortion problems with the thick visors, particularly if the eyewear was scratched or dirty.

ANNEX E – TASK PERFORMANCE

1. Introduction

Visor effects on the performance of military tasks were evaluated for select combat activities (obstacle course, firing range, OP surveillance, jungle lane, and pugil fighting). Visor effects on the performance of battle tasks were also evaluated for FIBUA warfare and night patrolling. Participant performance data and ratings, and HF observer assessments were collected during each task. Tasks were performed in all visor conditions.

2. Method

Each of the military and battle task test methods are described in the following section.

2.1 Obstacle Course: The following combat activities were undertaken consecutively as part of single course. At the completion of the obstacle course for each visor condition, participants completed a Task Questionnaire. The course was completed in Fighting order.

The following obstacles were used:

- **100m Dash:** Run 100m;
- **Ladder Obstacle:** Ascend a 10m ladder, straddle and traverse the top bar, then descend the ladder to the ground (Figure E-1);
- **Crawl:** Perform a Leopard crawl for 10m under a low wire obstacle (Figure E-2);
- **Irish Stones:** Leap one-footed from stone to stone to cross a sandpit;
- **Wall Obstacle:** Run and climb over three low walls spaced 3m apart;
- **Pit Obstacle:** Run up a 2m ramp, jump down into a sandpit, and perform a forward roll;
- **Balance Beam:** Walk along a zigzag balance beam mounted 0.5 m above the ground;
- **Over and Under Obstacle:** Climb over and under three successive poles mounted 0.5 and 1.0 meter from the ground; and
- **Mouse Hole Obstacle:** Crawl through a square, concrete mouse hole shaft for 1m and climb over and under three successive poles mounted 0.5m, 1.0m, and 0.5m above the ground.

Figure E-1: Ladder Obstacle

Figure E-2: Low Wire Obstacle

2.2 Range Firing (Figure E-3): Using a small arms range, participants performed the following modified personal weapons test serials with the C7A1 rifle.

Serial 1: Grouping and zeroing at 100m (prone).

Serial 2: Fire and Movement starting in the prone position at 400m.
a) Double to 300m (prone unsupported, two Figure 11 targets).
b) Double to 200m (kneeling supported, two Figure 11 targets).
c) Double to 100m (prone unsupported, two Figure 12 targets).
d) Walk to 50m (standing, snapshooting, one Figure 11 target).

Participant performance was evaluated using target range scoring; the High Point Score (HPS) was a maximum of 32 points. Participants were required to rate the firing performance, stability, and comfort of each visor condition. At the completion of range firing, participants completed a Task Questionnaire for each condition.

Figure E-3: C7A1 Range Firing

2.3 OP Surveillance: For all visor and no visor conditions, participants were required to detect and recognize 3D Figure 11 targets in the wood line. Presentation of 3D Figure 11 targets was performed using the radio-controlled Static Infantry Target (SIT) system (Figure E-4).

Figure E-4: Static Infantry Target in Woodline

Test participants were positioned between 50 and 80 m from an encircling wood line, with their vision blocked, and wearing ear plugs to prevent auditory detection of the target being raised. Eight 3D Figure 11 targets, positioned at set angles (22^{o} intervals from the horizontal periphery) in the participant's visual field, remained hidden from view until electronically triggered. Once triggered, the SIT swung up into a "standing" position at the edge of the wood line. The participant's vision was unblocked and the time to target detection was recorded (Figure E-5). HF observers recorded the participant's acceptance rating.

Figure E-5: OP Surveillance Task

2.4 Jungle Lane: The jungle lane test comprised a trail bounded on either side by a line of dense bush. Participants were required to advance down the trail, detect and fire upon Static Infantry Targets (SIT) (Figure E-6). The participant wore earplugs to prevent auditory detection of the target being raised. The HF observer accompanied the participant and triggered the presentation of the SIT 3D Figure 11 targets. Upon detection, the participant engaged the target with blank fire using their C7A1 rifle.

Figure E-6: Jungle Lane Task

The HF observers recorded the time from target presentation to first round fired as a measure of target detection and initial engagement. The HF observer recorded an overall acceptance rating for each visor at the completion of each jungle lane test.

2.5 Pugil Fighting: Participants engaged in pugil fighting (Figure E-7) to simulate crowd control conditions (i.e. defensive and offensive head and body movements, blows to the head, vision demands of close-in fighting, etc.). At the completion of the pugil boute, participants were required to complete a Task Questionnaire for each visor type.

Figure E-7: Pugil Fighting Task

2.6 Paint-Ball Capture-the-Flag: Participants were required to engage in FIBUA warfare simulation (Figure E-8). One Section occupied the flag home base at the start of each game (defenders). The flag home base was situated behind the concrete bunker in the training area north of the new FIBUA site. The other Section (attackers) advanced 100m from the north through a wooded area and along two possible tracks, which converged on the concrete bunker, using Section fire and movement tactics. The attackers were required to fight up to and around the bunker building to capture the flag. Both sections were issued paint-ball weapons and ammunition, pyrotechnics (i.e. smoke and thunderflashes), as well as disposable coveralls to protect their clothing.

Figure E-8: Paintball FIBUA Task

Game play ceased when the attacking Section captured the flag or at the end of 45 minutes of play. At the completion of each game, participants completed a Task Questionnaire for the visor condition tested. The order of conditions was balanced within each Section. At the completion of each game, participants exchanged visors and set up for the next game.

2.7 Fighting Patrols (Night): Participants were required to perform three night patrols. One Section tested the two thin visors (i.e. flat and curved) while the other Section tested the two thick visors. All participants also performed a no-visor baseline patrol. Participants rated the effectiveness in all visor conditions tested. HF observers evaluated glare, adaptation, and night vision performance effects through interviews with participants following the patrols.

Each Section performed a stealthy patrol along a wooded double track where they were "bumped" by an ambushing enemy force. The ambushing enemy force comprised SIT target systems and Light Hostile Fire Simulators (LHFS). Each ambush was initiated electronically on a signal from the HF observer when the section crossed predetermined waypoints on the trail. Glare sources (e.g. flares, vehicle headlights) were also introduced during the ambush portions of the patrol.

Once bumped the Section performed standard skirmishing fire and movement to suppress, advance, and assault the enemy position. At the completion of each engagement, participants completed a Task Questionnaire to rate each visor condition. The order of conditions was balanced within each Section. At the completion of the patrol, participants exchanged visors and repeated the drill.

3. Results

Summary results are provided for each military and battle task test in the following sections.

3.1 Obstacle Course
3.2 Range Firing
3.3 OP Surveillance
3.4 Jungle Lane
3.5 Pugil Fighting
3.6 Paint Ball
3.7 Fighting Patrols

In each case, the summary data are displayed graphically and the descriptive statistics and statistical comparisons are provided in the associated appendices.

3.1 Obstacle Course:

Results for the Obstacle Course task questionnaire are summarized below in Figures E-9 and E-10. Appendix 1 to this annex includes a tabular listing of all descriptive data obtained from the task questionnaire. Significant differences of $p \leq 0.05$ are identified between visor conditions.

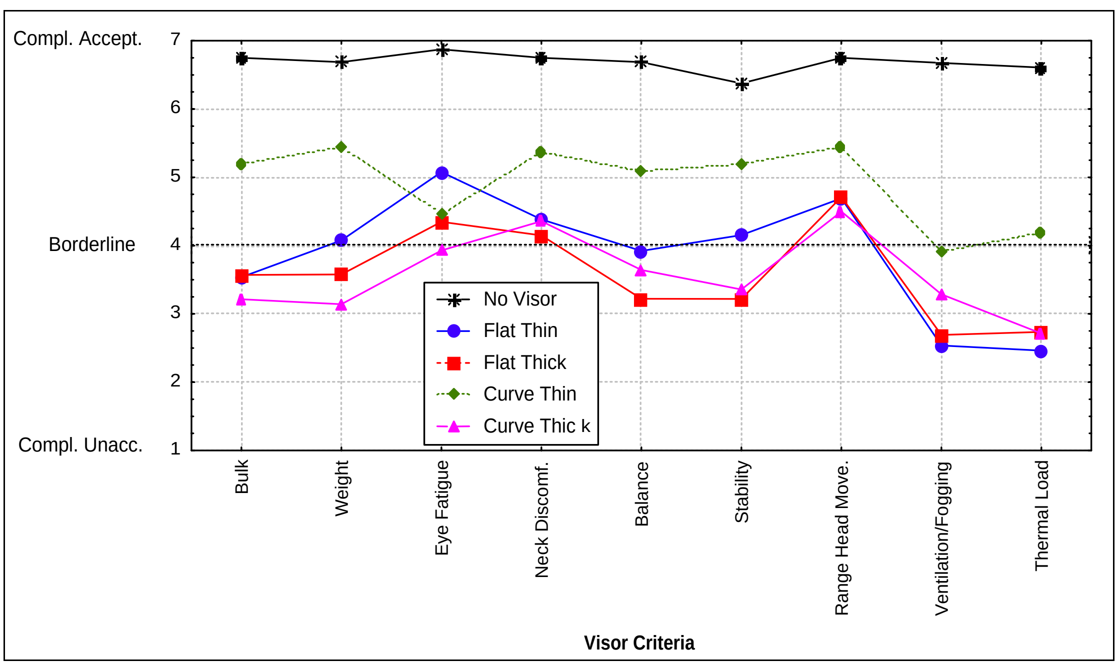


Figure E-9: Obstacle Course Task Questionnaire Data

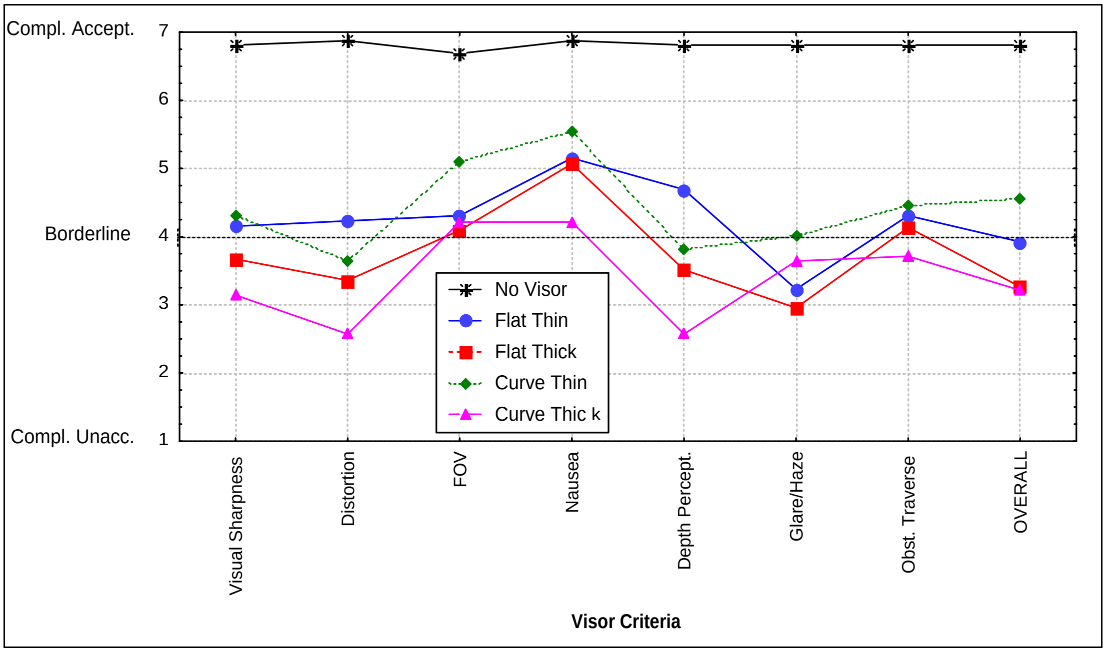


Figure E-10: Obstacle Course Task Questionnaire Data

Overall, all visor conditions were significantly less favourable than the no visor baseline.

The Curved Thin visor was rated more favourably than all other visors for:

- Bulk, Weight, and Thermal Load,

and was rated more favourably than both the flat and curved thicks visors for:

- Balance, Stability and Overall rating.

Only the Curved Thin visor was rated as generally acceptable for use on the obstacle course or for related activities.

3.2 Range Firing:

Results for the Range Firing task questionnaire are summarized below in Figures E-11, E-12 and E-13. Appendix 2 to this annex includes a tabular listing of all descriptive data obtained from the task questionnaire. Range firing scores are summarized in Figure E-14. Significant differences of $p \leq 0.05$ are identified between visor conditions.

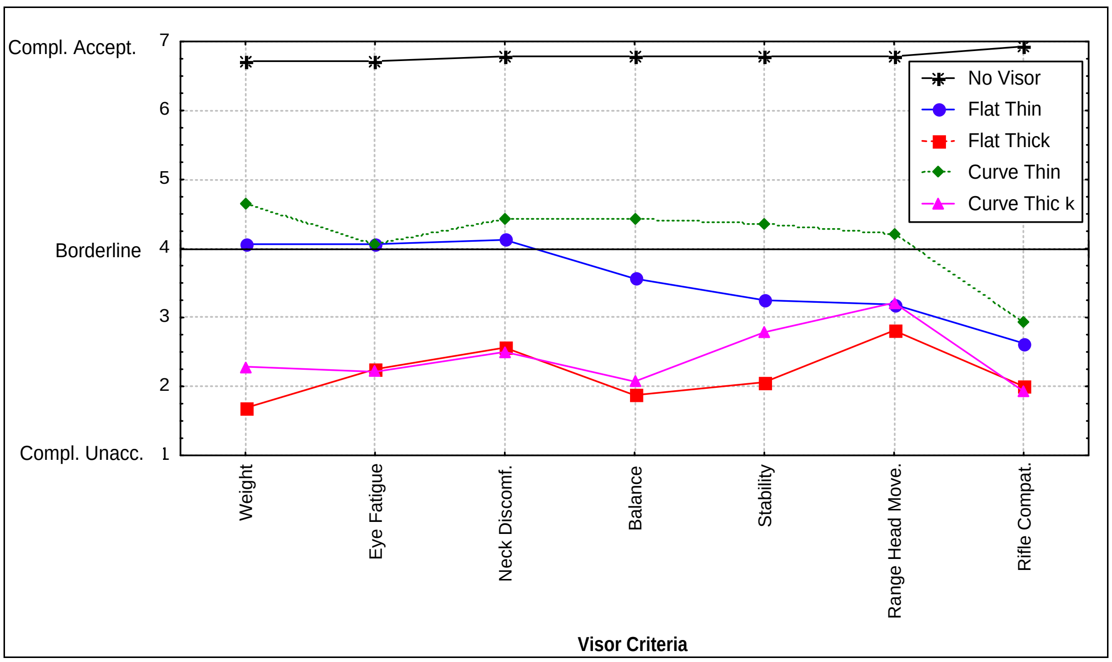


Figure E-11 (1 of 3): Range Firing Task Questionnaire Data

For the data summarized in Figure E-11, all visors conditions were rated as significantly less favourable than the no visor baseline. Most of these were "unacceptable", with the exception of the Curved Thin visor. The flat thin visor was rated as borderline for weight, eye fatigue and neck discomfort. The thin visors were preferred over the thick visors for weight, eye fatigue, neck discomfort and balance on the head. The Curved Thin visor was preferred to the Flat Thin visor for stability and to the thick visors for stability, range of head movement and rifle compatibility.

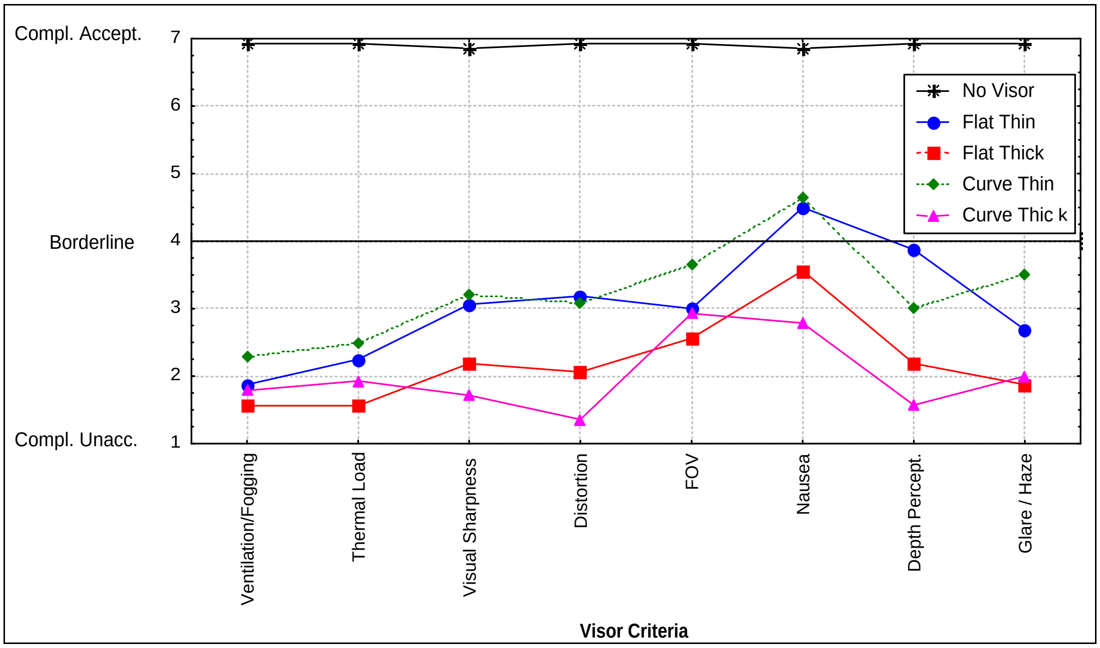


Figure E-12 (2 of 3): Range Firing Task Questionnaire Data

For the data summarized in Figure E-12, all visor conditions were rated significantly less favourably than the no visor baseline. All visor ratings in Figure E-12 were "unacceptable", with the exception of the thin visors for ratings of nausea. While the rating were "reasonably to completely unacceptable" for thermal load, the thin visors were statistically preferred to the thick visors. Participants reported that all visors were prone to fogging, presented a high thermal load while performing vigorous activities, and introduced glare/haze while worn.

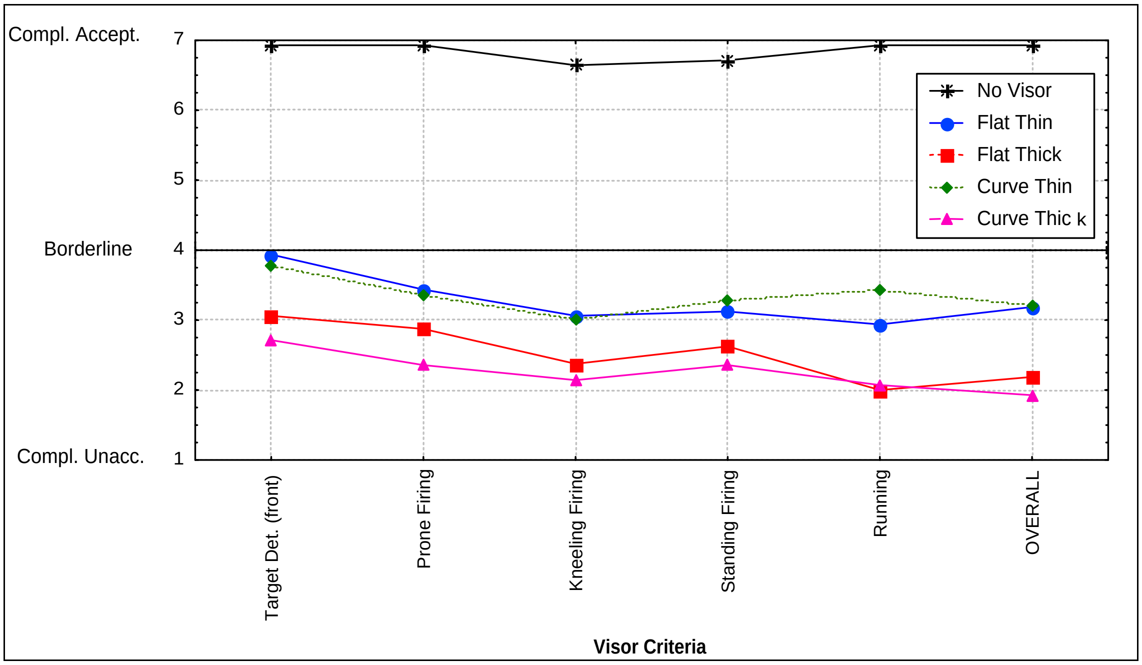


Figure E-13 (3 of 3): Range Firing Task Questionnaire Data

For the data summarized in Figure E-13, all visor conditions were rated significantly less favourably than the no visor baseline and all visor were rated as “unacceptable”. The Curved Thin visor was preferred to the thick visors for running.

Generally, for range firing tasks, thin visors were rated more favourably than thick visors for:

- Weight, Eye Fatigue, Neck Discomfort, and Balance.
- Visual Sharpness, Distortion, and Overall ratings.

While the Curved Thin visor produced some acceptable ratings, all visors were generally rated as unacceptable for rifle firing.

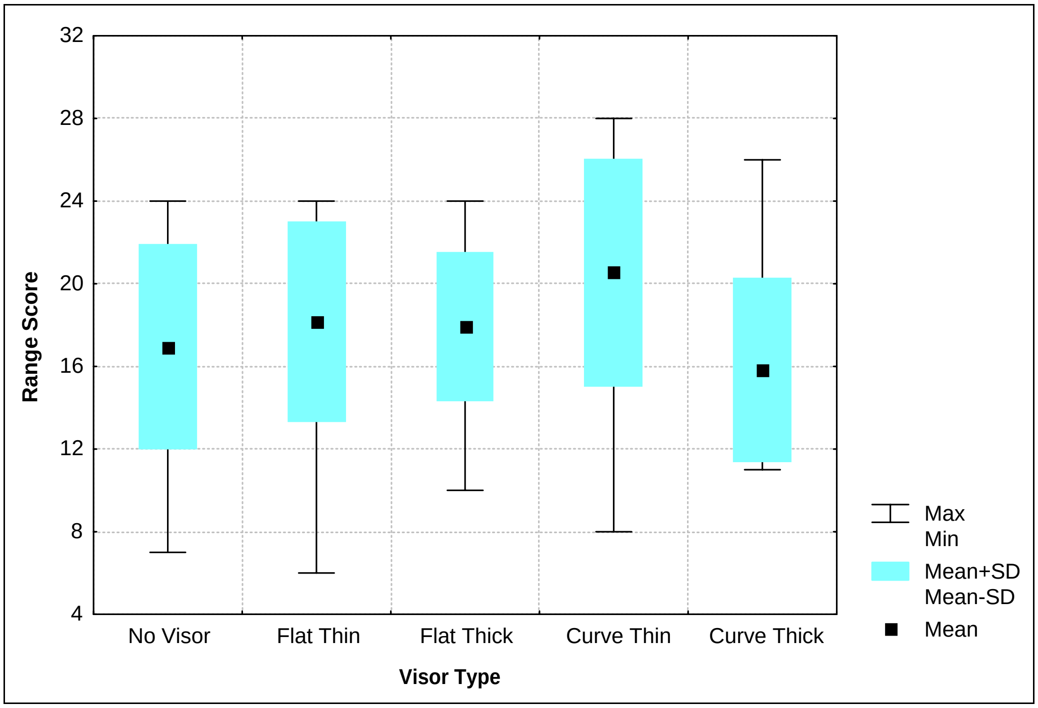


Figure E-14: C7A1 Range Scores

Range firing scores did not reveal any significant differences between visors and the no visor baseline, and there were no statistical differences between visor conditions.

3.3 OP Surveillance:

Results for the OP Surveillance task questionnaire are summarized below in Figure E-15. Appendix 3 to this annex provides a tabular listing of all descriptive data obtained from the task questionnaire. Significant differences of $p \leq 0.05$ are identified between visor conditions. Target Detection times are summarized in Figure E-16.

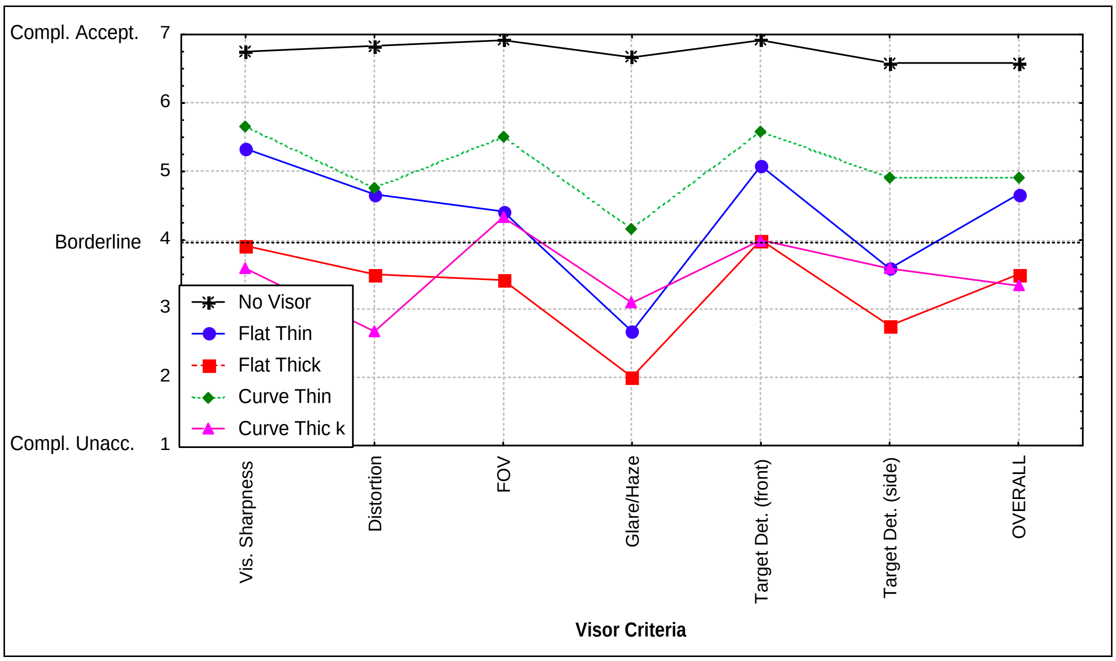


Figure E-15: OP Surveillance Task Questionnaire Data

Generally, the Thin visors were rated as acceptable and more favourably than the Thick visors (typically rated as unacceptable).

The Curved Thin visor was rated significantly higher than all other visors for Field of View, Target Detection (sides), and Glare/Haze.

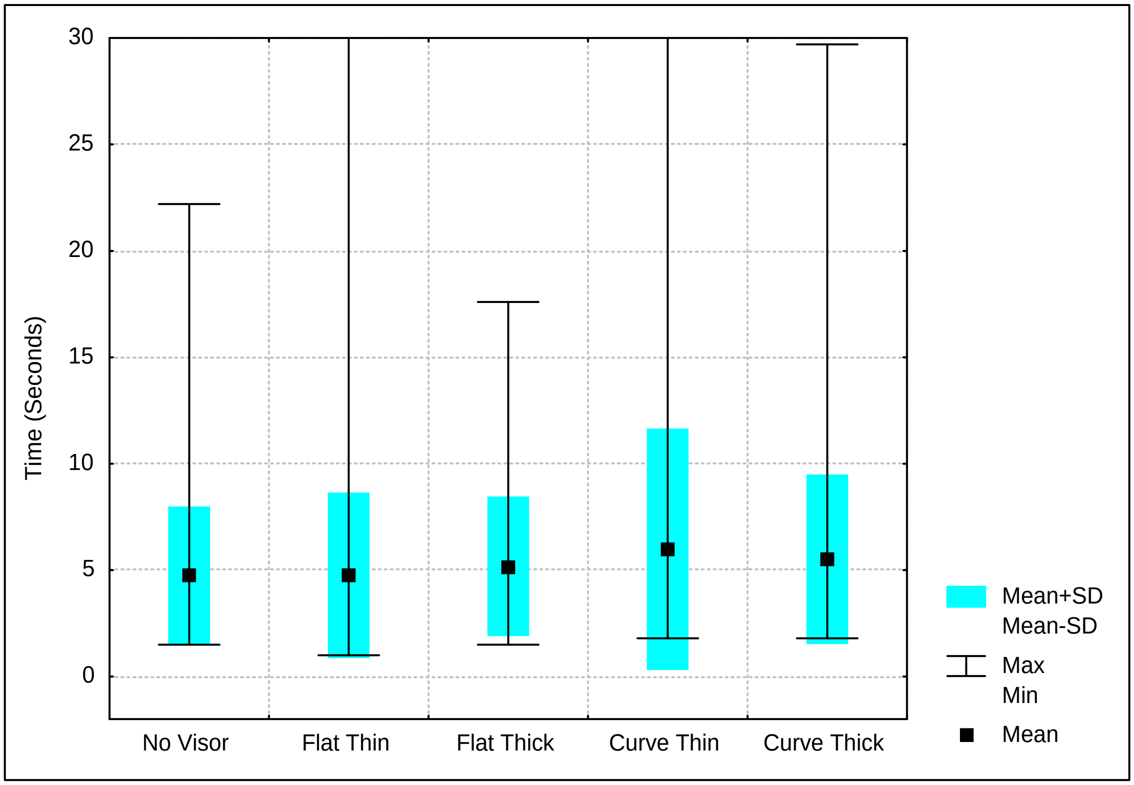


Figure E-16: OP Surveillance Target Detection Time Data

There were no significant differences in target detection times between visors and the no visor baseline, or between visor conditions.

3.4 Jungle Lane:

Results for the Jungle Lane task questionnaire are summarized below in Figures E-17 and E-18. Appendix 4 to this annex includes a tabular listing of all descriptive data obtained from the task questionnaire. Significant differences of $p \leq 0.05$ are identified between visor conditions. Target Detection times are summarized in Figure E-19.

Generally, the Curved Thick visor was rated significantly less favourably than the other visors for:

- Distortion, Nausea, Depth Perception, and Overall Acceptability

Except for the Curved Thick visor, the other visors were rated as acceptable for Jungle Lane firing.

There were no significant differences between the times to detect and engage the targets between the no visor or visor conditions, or between visor conditions themselves (Figure E-19).

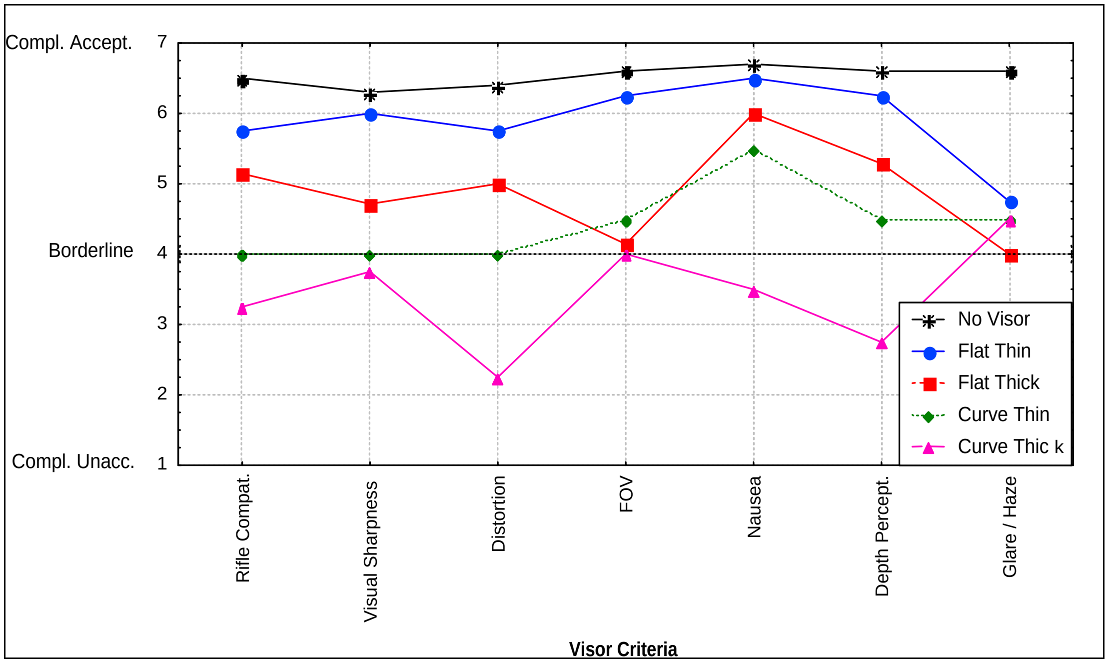


Figure E-17: Jungle Lane Task Questionnaire Data

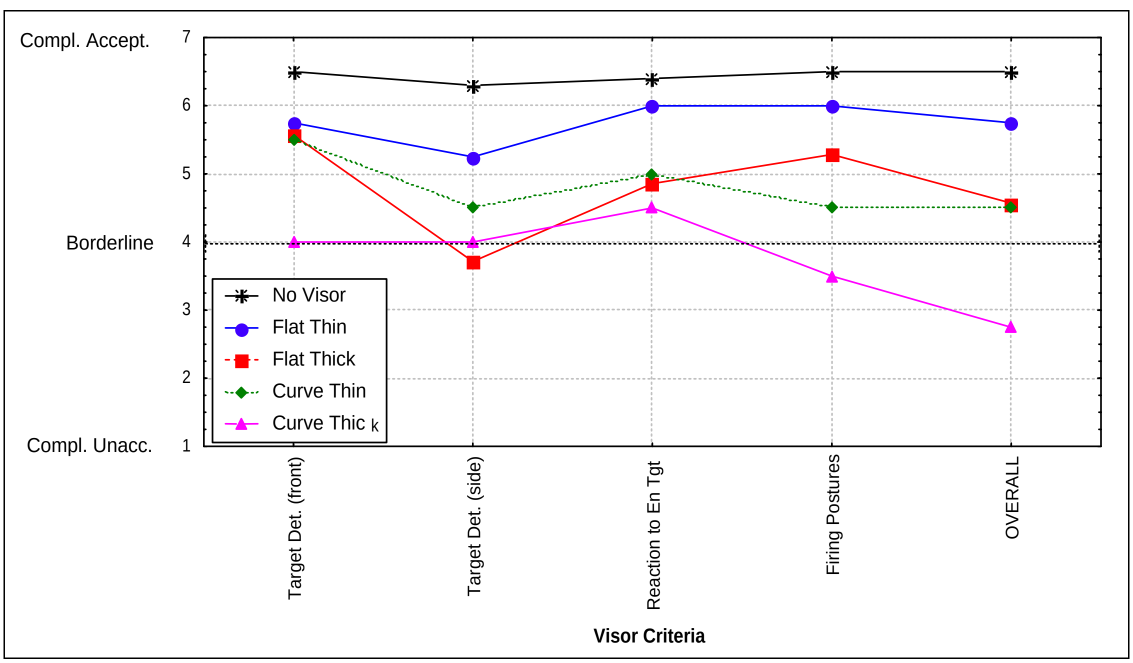


Figure E-18: Jungle Lane Task Questionnaire Data

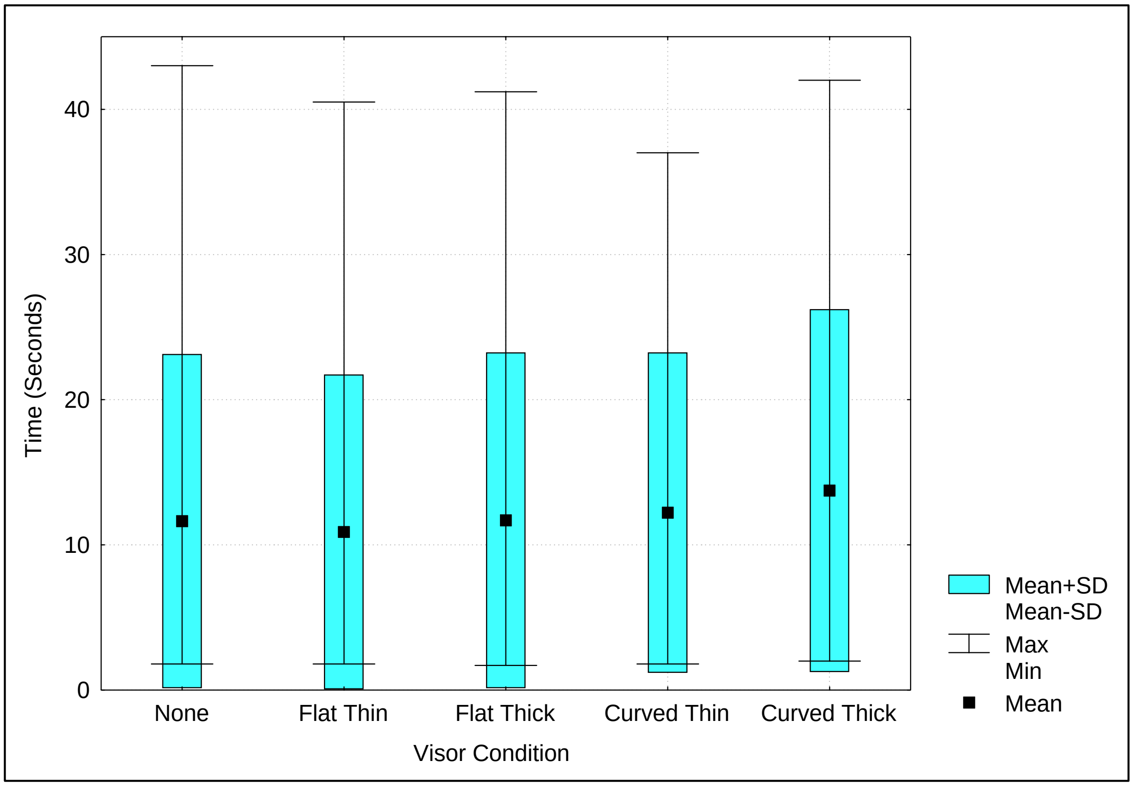


Figure E-19: Jungle Lane Target Detection Time Data

3.5 Pugil Fighting:

Results for the Pugil Fighting task questionnaire are summarized below in Figures E-20 and E-21. Appendix 5 to this annex includes a tabular listing of all descriptive data obtained from the task questionnaire. Significant differences of $p \leq 0.05$ are identified between visor conditions.

Generally, there were no significant visor differences between visor conditions. Visors were rated as unacceptable for pugil fighting, with the exception of the Curved Thin visor, for balance, range of head movement, speed of head movement, and nausea.

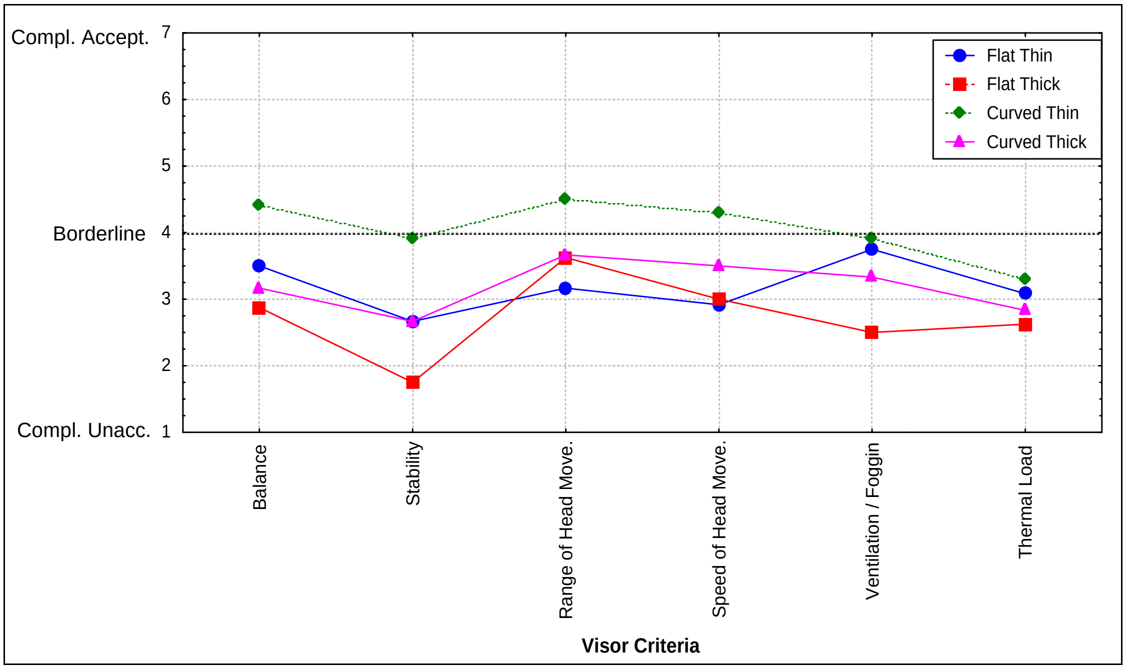


Figure E-20 (1 of 2): Pugil Fighting Task Questionnaire Data

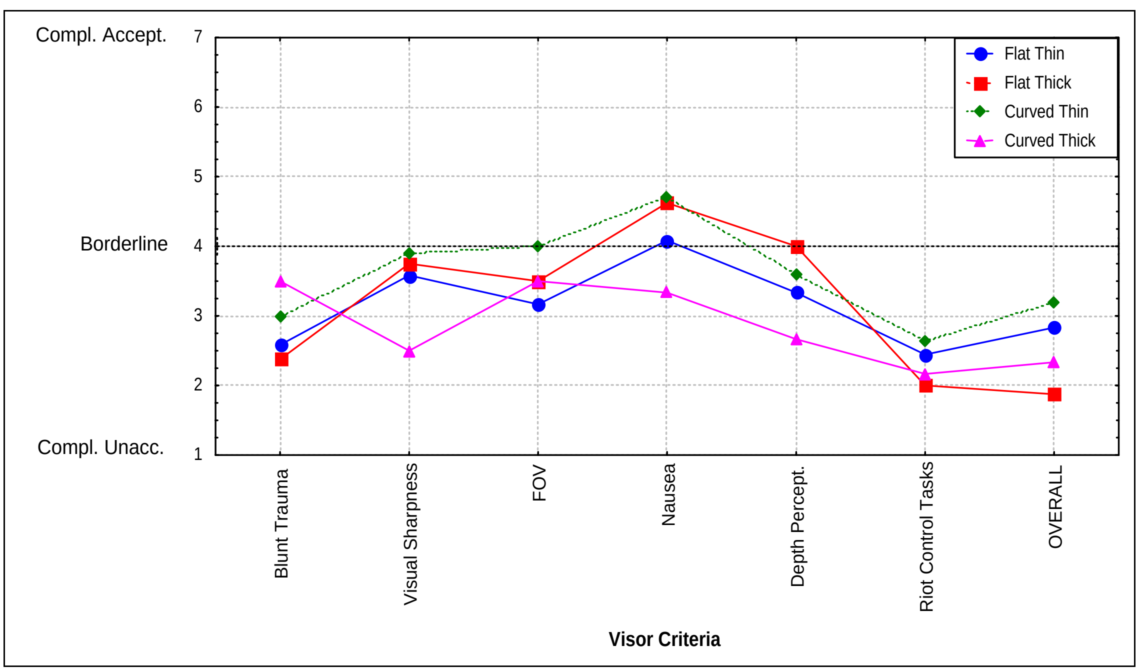


Figure E-21 (2 of 2): Pugil Fighting Task Questionnaire Data

3.6 Paint-Ball Capture-the-Flag:

Results for the Paint Ball/Capture-the-Flag task questionnaire are summarized below in Figures E-22, E-23 and E-24. Appendix 6 to this annex includes a tabular listing of all descriptive data obtained from the task questionnaire. Significant differences of $p \leq 0.05$ are identified between visor conditions.

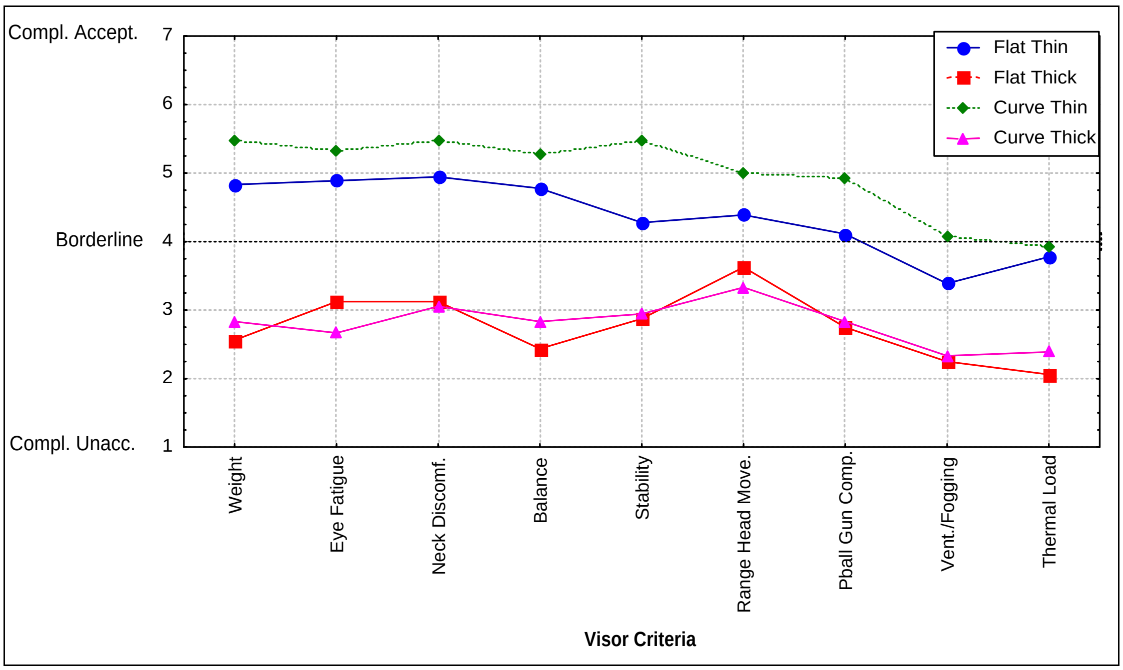


Figure E-22: Paintball Task Questionnaire Data

For the data summarized in Figure E-22, both thin visor conditions were rated significantly more favourably than the thick visors for weight, eye fatigue, neck discomfort, balance, stability and thermal load. The Curved Thin visor also rated more favourably for range of head movement, paint-ball weapon compatibility, and ventilation/fogging. Generally, thin visors were rated as "acceptable" and thick visors were "barely to reasonably unacceptable".

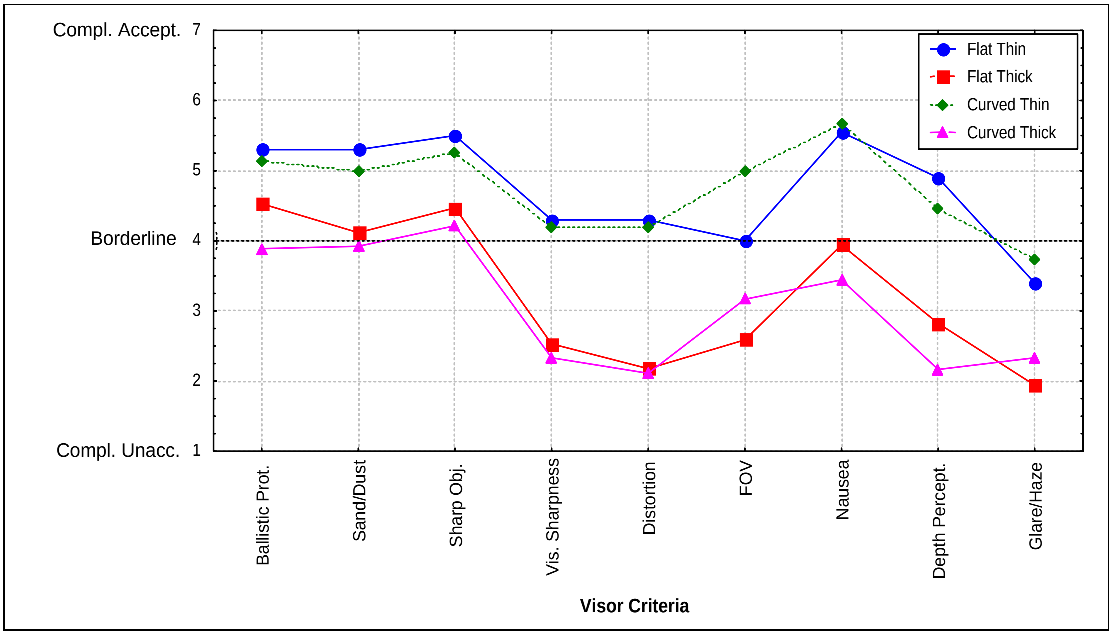


Figure E-23: Paintball Task Questionnaire Data

For the data summarized in Figure E-23, both thin visor conditions were rated significantly more favourably than the thick visors for protection against sand/dust and sharp objects, visual sharpness, distortion and field of view, nausea and depth perception. The Curved Thin visor also rated more favourably than all other visors for visual glare and haze. Generally, thin visors were rated as “acceptable” and thick visors were “borderline to reasonably unacceptable”.

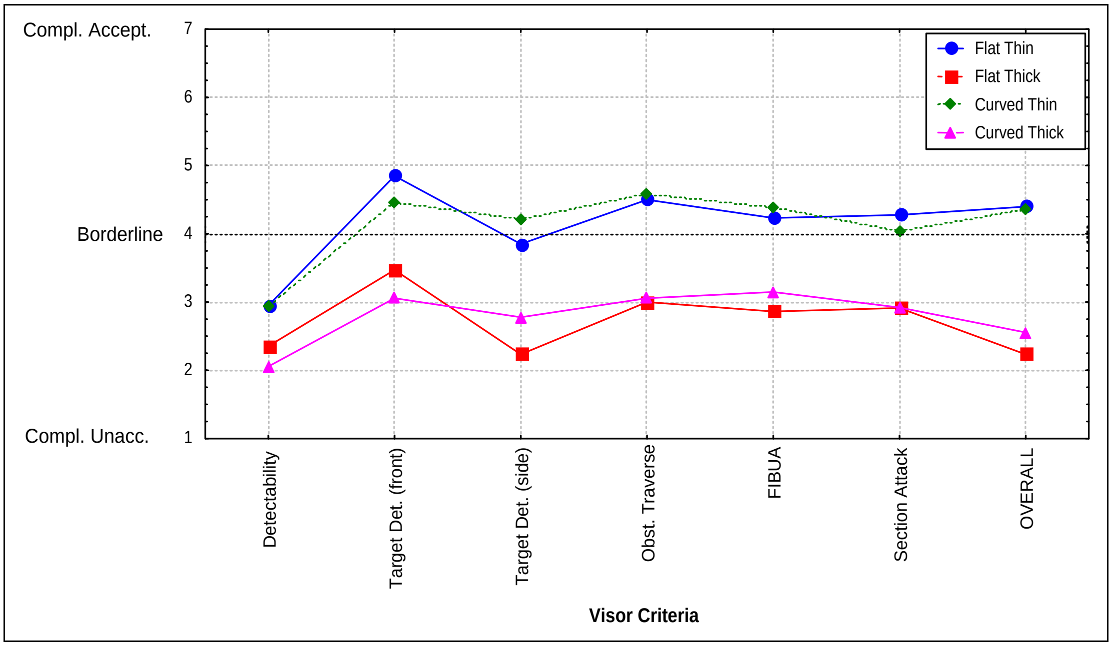


Figure E-24: Paintball Task Questionnaire Data

For the data summarized in Figure E-24, both thin visor conditions were rated significantly more favourably than the thick visors for obstacle traverse, Section attacks, and overall ratings. With the exception of detectability, thin visors were rated as "borderline to barely acceptable" and thick visors were rated as "barely unacceptable". The Flat Thin visor was also preferred to the thick visors for target detection to the front. All visors were rated as "barely to reasonably unacceptable" for an enemy's ability to detect the visors.

3.7 Fighting Patrols (Night):

Results for the Night Patrol task questionnaire are summarized below in Figures E-25, E-26 and E-27. Appendix 7 to this annex includes a tabular listing of all descriptive data obtained from the task questionnaire. Significant differences of $p \leq 0.05$ are identified between visor conditions.

Generally, there was no significant rating difference between visor conditions. The thin visors were rated significantly more favourably than the thick visors for balance on the head. Only the Curved Thin visor was rated as "barely acceptable" for factors related to forces on the head and neck. Generally, ratings ranged from "borderline to reasonably unacceptable".

Overall, participants rated all visors as unacceptable for night use.

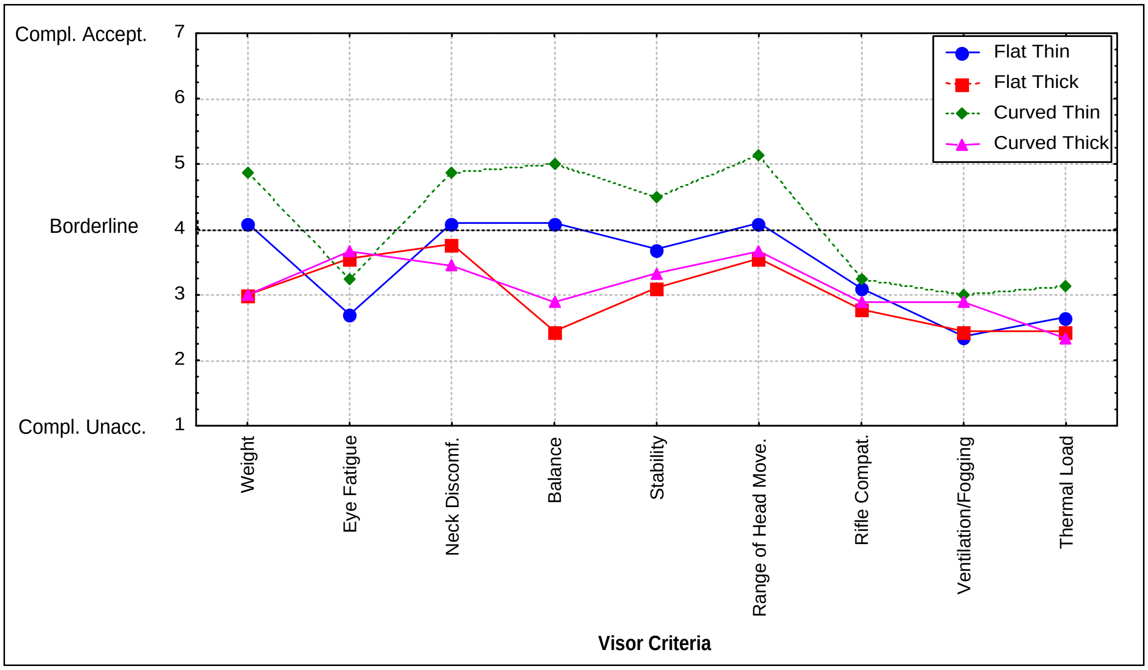


Figure E-25: Fighting Patrol (Night) Task Questionnaire Data

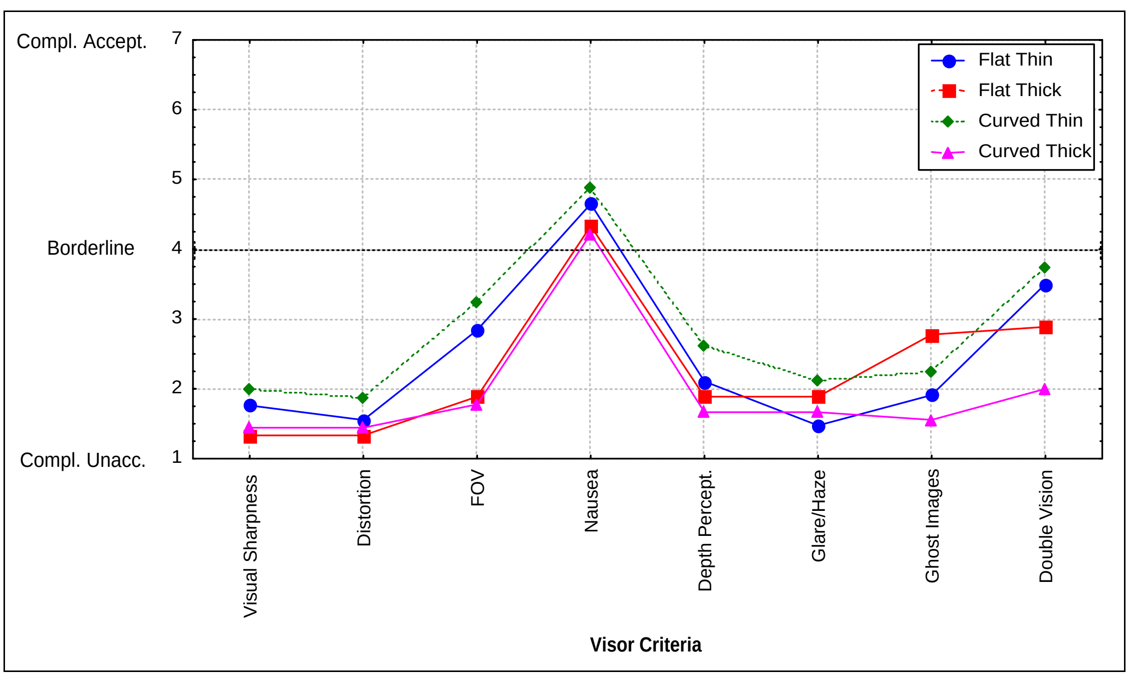


Figure E-26: Fighting Patrol (Night) Task Questionnaire Data

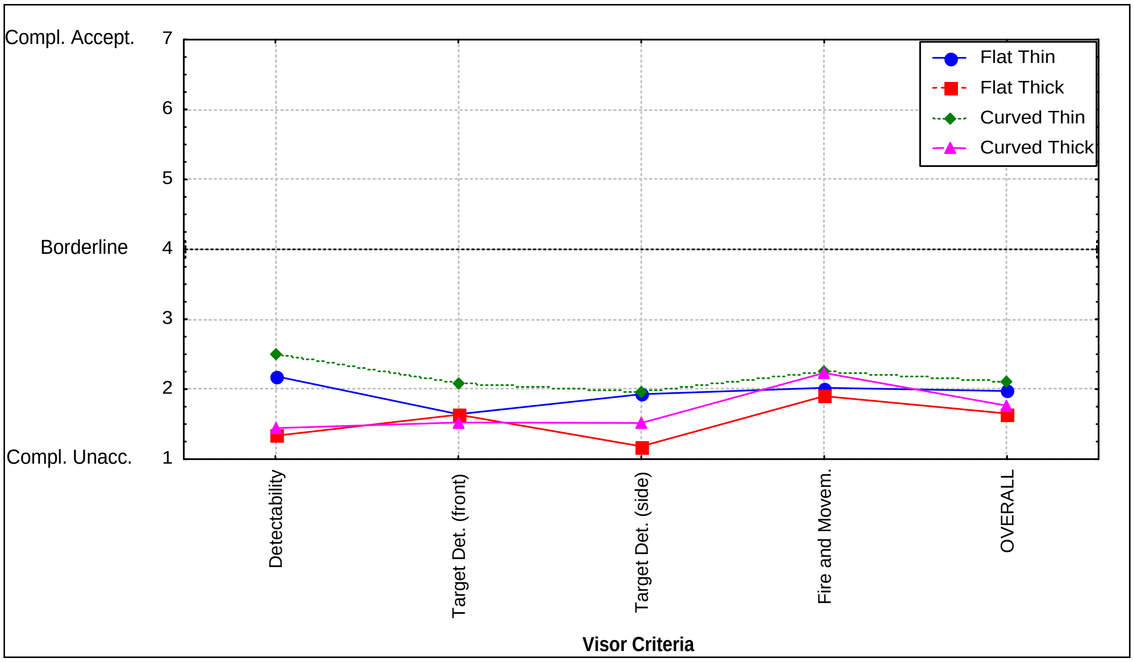


Figure E-27: Fighting Patrol (Night) Task Questionnaire Data

4. Discussion

4.1 Obstacle Course

Overall, the visor ratings were significantly less favourable than the no visor condition. Participants reported that the bulk, weight and balance of the visors (particularly the thick visors) impeded their performance on the obstacle course, with the exception of the Curved Thin visor. Only the Curved Thin visor was rated as generally acceptable.

4.2 Range Firing

Questionnaire data revealed that the participants generally rated the visors as unacceptable for rifle firing. While thin visors tended to be rated more favourably than thick visors for load effects and visual performance, only the Curved Thin visor achieved "barely acceptable" ratings for factors affecting load force effects on the head and neck. The results from the range firing, however, revealed that range firing performance was not affected by visor wear. This apparent anomaly can be explained by the participant's ability to overcome the compatibility limitations of the visors during rifle firing. To achieve a good sight picture, participants needed to position the nose cutout of the visor over the ridge of the butt of the weapon and then move their heads into correct position within the helmet. Participants reported that they had sufficient time on the range to reposition the head and visor, although concerns were raised regarding any delay in sighting a weapon during actual combat.

4.3 OP Surveillance

Generally, thin visors were rated as acceptable and were preferred to thick visors (typically unacceptable). The Curved Thin visor was rated significantly more favourably than the other visor conditions for field of view, target detection to the sides, and glare/haze. There were no performance differences in the time to detect targets between the no visor baseline and the visor conditions, and no difference between visors.

4.4 Jungle Lane

The visors were reported as acceptable for jungle lane firing, with the exception of the Curved Thick visor. The curved thick visor was reported as causing depth perception and visual distortion problems as well as inducing feelings of nausea in some participants. The nausea effects were most pronounced during the target acquisition phase of the jungle lane task. There were no performance differences in the time to detect and engage targets between the no visor baseline and the visor conditions, and no difference between visors.

4.5 Pugil Fighting

The participants unanimously agreed that the visors were unacceptable for use during pugil fighting or related tasks. Generally, there were no significant differences between visor conditions. Visors were rated as unacceptable, with the exception of the Curved Thin visor for balance, range of head movement, speed of head movement, and nausea.

4.6 PaintBall/Capture-the-Flag

The thin visors were generally rated as acceptable and significantly more favourable than the thick visors (typically rated as unacceptable).

4.7 Fighting Patrol (Night)

The participants reported that the visors were unacceptable for use on night patrols. With the exception of thin visors being favoured over thick visor for balance, there were no appreciable differences between visor conditions.

Appendix 1 to
Annex E:
Obstacle Course Descriptive Data Summary

Descriptive Data					Significant Differences ($p \leq 0.05$)				
Feature	Visor Type	N	Mean	s.d.	None	Fthin	Fthick	Cthin	Cthick
Bulk on Head	None	16	6.8	0.4		√	√	√	√
	Flat thin	13	3.5	1.6	√			√	
	Flat thick	19	3.5	2.2	√			√	
	Curved thin	11	5.2	1.5	√	√	√		√
	Curved thick	14	3.2	1.8	√			√	
Weight on Head	None	16	6.7	0.5		√	√		√
	Flat thin	13	4.1	1.6	√			√	
	Flat thick	19	3.5	2.2	√			√	
	Curved thin	11	5.5	1.4		√	√		√
	Curved thick	14	3.1	1.7	√			√	
Eye Fatigue/ Headaches	None	16	6.9	0.3		√	√	√	√
	Flat thin	13	5.1	1.1	√				
	Flat thick	19	4.3	2.1	√				
	Curved thin	11	4.5	2.0	√				
	Curved thick	14	3.9	2.2	√				
Neck Discomfort	None	16	6.8	0.4		√	√	√	√
	Flat thin	13	4.4	1.5	√				
	Flat thick	19	4.1	2.4	√				
	Curved thin	11	5.4	1.2	√				
	Curved thick	14	4.4	1.6	√				
Balance on Head	None	16	6.7	0.6		√	√	√	√
	Flat thin	13	3.9	1.7	√				
	Flat thick	19	3.2	2.3	√			√	
	Curved thin	11	5.1	1.6	√		√		√
	Curved thick	14	3.6	1.7	√			√	
Stability on Helmet	None	16	6.3	1.8		√	√		√
	Flat thin	13	4.2	1.7	√				
	Flat thick	19	3.2	2.3	√			√	
	Curved thin	11	5.2	1.1	√		√		√
	Curved thick	14	3.4	1.7	√			√	
Range of Head Movement	None	16	6.8	0.6		√	√	√	√
	Flat thin	13	4.7	1.9	√				
	Flat thick	19	4.7	2.0	√				
	Curved thin	11	5.5	1.4	√				
	Curved thick	14	4.5	1.5	√				
Ventilation/ Fogging	None	16	6.4	1.8		√	√	√	√
	Flat thin	13	2.5	1.7	√				
	Flat thick	19	2.6	1.7	√				
	Curved thin	11	3.9	2.0	√				
	Curved thick	14	3.3	1.7	√				
Thermal Load	None	16	6.4	1.8		√	√	√	√
	Flat thin	13	2.5	1.7	√			√	
	Flat thick	19	2.7	1.6	√			√	
	Curved thin	11	4.2	1.7	√	√	√		√
	Curved thick	14	2.7	1.5	√			√	
Visual Sharpness	None	16	6.8	0.5		√	√	√	√
	Flat thin	13	4.2	1.4	√				
	Flat thick	19	3.6	1.7	√				
	Curved thin	11	3.9	2.0	√				
	Curved thick	14	3.1	1.9	√				

Appendix 1 to Annex E: Obstacle Course Descriptive Data Summary

Descriptive Data					Significant Differences ($p \leq 0.05$)				
Feature	Visor Type	N	Mean	s.d.	None	Fthin	Fthick	Cthin	Cthick
Visual Distortion	None	16	6.9	0.3		√	√	√	√
	Flat thin	13	4.2	1.4	√				√
	Flat thick	19	3.3	1.7	√				
	Curved thin	11	3.6	1.7	√				
	Curved thick	14	2.6	1.6	√	√			
Field of View	None	16	6.7	1.0		√	√	√	√
	Flat thin	13	4.3	1.8	√				
	Flat thick	19	4.1	2.0	√				
	Curved thin	11	5.1	1.8	√				
	Curved thick	14	4.2	1.9	√				
Nausea	None	16	6.9	0.3		√	√		√
	Flat thin	13	5.2	1.3	√				
	Flat thick	19	5.1	1.7	√				
	Curved thin	11	5.5	1.6					√
	Curved thick	14	4.2	2.4	√			√	
Depth Perception	None	16	6.8	0.5		√	√	√	√
	Flat thin	13	4.7	1.3	√				√
	Flat thick	19	3.5	1.7	√				
	Curved thin	11	3.8	2.3	√				
	Curved thick	14	2.6	2.2	√	√			
Visual Glare/ Haze	None	16	6.8	0.8		√	√	√	√
	Flat thin	13	3.2	1.5	√				
	Flat thick	19	2.9	1.8	√				
	Curved thin	10	4.0	2.2	√				
	Curved thick	14	3.6	1.5	√				
Obstacle Traverse	None	16	6.8	0.5		√	√	√	√
	Flat thin	13	4.3	1.4	√				
	Flat thick	19	4.1	1.9	√				
	Curved thin	11	4.5	2.1	√				
	Curved thick	14	3.7	2.1	√				
Overall Rating	None	16	6.8	0.5		√	√	√	√
	Flat thin	13	3.9	1.5	√				
	Flat thick	19	3.2	1.7	√			√	
	Curved thin	11	4.5	1.8	√		√		√
	Curved thick	14	3.2	1.8	√			√	

Appendix 2 to
Annex E:
Range Firing Descriptive Data Summary

Descriptive Data					Significant Differences ($p \leq 0.05$)				
Feature	Visor Type	N	Mean	s.d.	None	Fthin	Fthick	Cthin	Cthick
Weight on Head	None	14	6.7	0.6		√	√	√	√
	Flat thin	14	4.1	1.7	√		√		√
	Flat thick	14	1.7	1.1	√	√		√	
	Curved thin	14	4.6	1.4	√		√		√
	Curved thick	14	2.1	1.1	√	√		√	
Eye Fatigue/ Headaches	None	14	6.7	0.6		√	√	√	√
	Flat thin	14	4.1	1.9	√		√		√
	Flat thick	14	2.3	1.1	√	√		√	
	Curved thin	14	4.1	1.5	√		√		√
	Curved thick	14	2.0	1.3	√	√		√	
Neck Discomfort	None	14	6.8	0.4		√	√	√	√
	Flat thin	14	4.1	1.6	√		√		√
	Flat thick	14	2.6	1.5	√	√		√	
	Curved thin	14	4.4	1.6	√		√		√
	Curved thick	14	2.3	1.4	√	√		√	
Balance on Head	None	14	6.8	0.4		√	√	√	√
	Flat thin	14	3.6	1.5	√		√		√
	Flat thick	14	1.9	1.3	√	√		√	
	Curved thin	14	4.4	1.5	√		√		√
	Curved thick	14	1.8	1.1	√	√		√	
Stability on Helmet	None	14	6.8	0.4		√	√	√	√
	Flat thin	14	3.3	1.5	√			√	
	Flat thick	14	2.1	1.3	√	√		√	
	Curved thin	14	4.4	1.5	√	√	√		√
	Curved thick	14	2.6	1.7	√		√	√	
Range of Head Movement	None	14	6.8	0.4		√	√	√	√
	Flat thin	14	3.2	1.6	√				
	Flat thick	14	2.8	1.4	√			√	
	Curved thin	14	4.2	1.5	√		√		√
	Curved thick	14	3.1	1.6	√			√	
Rifle Compatibility	None	14	6.9	0.3		√	√	√	√
	Flat thin	14	2.6	1.5	√				
	Flat thick	14	2.0	0.8	√			√	
	Curved thin	14	2.9	1.5	√		√		√
	Curved thick	14	1.9	0.9	√			√	
Ventilation/ Fogging	None	14	6.9	0.3		√	√	√	√
	Flat thin	14	1.9	1.5	√				
	Flat thick	14	1.6	0.8	√				
	Curved thin	14	2.3	1.6	√				
	Curved thick	14	1.8	0.9	√				
Thermal Load	None	14	6.9	0.3		√	√	√	√
	Flat thin	14	2.3	1.3	√		√	√	√
	Flat thick	14	1.6	0.8	√	√		√	√
	Curved thin	14	2.5	1.3	√	√	√		√
	Curved thick	14	1.8	0.8	√	√	√	√	
Visual Sharpness	None	14	6.9	0.4		√	√	√	√
	Flat thin	14	3.1	1.7	√				
	Flat thick	14	2.2	0.9	√			√	
	Curved thin	14	3.2	1.3	√		√		
	Curved thick	14	1.7	1.2	√				

Appendix 2 to
Annex E:
Range Firing Descriptive Data Summary

Descriptive Data					Significant Differences ($p \leq 0.05$)				
Feature	Visor Type	N	Mean	s.d.	None	Fthin	Fthick	Cthin	Cthick
Visual Distortion	None	14	6.9	0.3		√	√	√	√
	Flat thin	14	3.2	1.8	√		√		√
	Flat thick	14	2.1	1.1	√	√		√	
	Curved thin	14	3.1	1.2	√		√		√
	Curved thick	14	1.3	0.6	√	√		√	
Field of View	None	14	6.9	0.3		√	√	√	√
	Flat thin	14	3.0	1.8	√				
	Flat thick	14	2.6	1.5	√				
	Curved thin	14	3.6	1.4	√				
	Curved thick	14	3.0	1.6	√				
Nausea	None	14	6.9	0.4		√	√	√	√
	Flat thin	14	4.5	2.2	√				√
	Flat thick	14	3.6	1.9	√				
	Curved thin	14	4.6	1.6	√				√
	Curved thick	14	2.6	1.8	√	√		√	
Depth Perception	None	14	6.9	0.3		√	√	√	√
	Flat thin	14	3.9	2.0	√		√		√
	Flat thick	14	2.2	1.4	√	√			
	Curved thin	14	3.0	1.6	√				√
	Curved thick	14	1.5	0.8	√	√		√	
Visual Glare/ Haze	None	14	6.9	0.3		√	√	√	√
	Flat thin	14	2.7	1.7	√		√		
	Flat thick	14	1.9	1.1	√			√	
	Curved thin	14	3.5	1.6	√		√		√
	Curved thick	14	2.0	1.3	√			√	
Target Detection (Front)	None	14	6.9	0.3		√	√	√	√
	Flat thin	14	3.9	1.9	√				
	Flat thick	14	3.1	1.6	√				
	Curved thin	14	3.8	1.5	√				
	Curved thick	14	2.8	1.7	√				
Prone Firing	None	14	6.9	0.3		√	√	√	√
	Flat thin	14	3.4	2.0	√				
	Flat thick	14	2.9	1.6	√				
	Curved thin	14	3.4	1.8	√				
	Curved thick	14	2.4	1.4	√				
Kneeling Firing	None	14	6.6	0.8		√	√	√	√
	Flat thin	14	3.1	1.8	√				
	Flat thick	14	2.4	1.4	√				
	Curved thin	14	3.0	1.7	√				
	Curved thick	14	2.2	1.2	√				
Standing Firing	None	14	6.7	0.6		√	√	√	√
	Flat thin	14	3.1	1.8	√				
	Flat thick	14	2.6	1.3	√				
	Curved thin	14	3.3	1.8	√				
	Curved thick	14	2.5	1.5	√				
Running	None	14	6.9	0.3		√	√	√	√
	Flat thin	14	2.9	1.9	√				
	Flat thick	14	2.0	1.3	√			√	
	Curved thin	14	3.4	1.9	√		√		√
	Curved thick	14	2.1	1.2	√			√	

Range Firing Descriptive Data Summary

Descriptive Data					Significant Differences ($p \leq 0.05$)				
Feature	Visor Type	N	Mean	s.d.	None	Fthin	Fthick	Cthin	Cthick
Overall Rating	None	14	6.9	0.3		√	√	√	√
	Flat thin	14	3.2	1.7	√		√		√
	Flat thick	14	2.2	1.2	√	√		√	
	Curved thin	14	3.2	1.5	√		√		√
	Curved thick	14	1.9	0.9	√	√		√	

Appendix 3 to Annex E: OP Surveillance Descriptive Data Summary

Descriptive Data					Significant Differences ($p \leq 0.05$)				
Feature	Visor Type	N	Mean	s.d.	None	Fthin	Fthick	Cthin	Cthick
Visual Sharpness	None	12	6.8	0.5		√	√	√	√
	Flat thin	12	5.3	0.7	√		√		√
	Flat thick	12	3.9	1.2	√	√		√	
	Curved thin	12	5.7	0.8	√		√		√
	Curved thick	12	3.6	1.6	√	√		√	
Visual Distortion	None	12	6.8	0.4		√	√	√	√
	Flat thin	12	4.7	1.2	√		√		√
	Flat thick	12	3.5	1.2	√	√		√	
	Curved thin	12	4.8	1.7	√		√		√
	Curved thick	12	2.7	1.5	√	√		√	
Field of View	None	12	6.9	0.3		√	√	√	√
	Flat thin	12	4.4	1.2	√			√	
	Flat thick	12	3.4	1.2	√			√	
	Curved thin	12	5.5	1.0	√	√	√		√
	Curved thick	12	4.3	1.7	√			√	
Visual Glare/ Haze	None	12	6.7	0.7		√	√	√	√
	Flat thin	12	2.7	1.3	√			√	
	Flat thick	12	2.0	0.9	√			√	√
	Curved thin	12	4.2	1.2	√	√	√		√
	Curved thick	12	3.1	1.4	√		√	√	
Target Detection (Front)	None	12	6.9	0.3		√	√	√	√
	Flat thin	12	5.1	0.9	√		√		√
	Flat thick	12	4.0	1.2	√	√		√	
	Curved thin	12	5.6	0.8	√		√		√
	Curved thick	12	4.0	1.6	√	√		√	
Target Detection (Sides)	None	12	6.6	0.8		√	√	√	√
	Flat thin	12	3.6	1.7	√			√	
	Flat thick	12	2.8	1.5	√			√	
	Curved thin	12	4.9	1.1	√	√	√		√
	Curved thick	12	3.6	1.5	√			√	
Overall Rating	None	12	6.6	0.7		√	√	√	√
	Flat thin	12	4.7	0.9	√		√		√
	Flat thick	12	3.5	1.3	√	√		√	
	Curved thin	12	4.9	1.4	√		√		√
	Curved thick	12	3.3	1.7	√	√		√	

Appendix 4 to Annex E: Jungle Lane Descriptive Data Summary

Descriptive Data					Significant Differences ($p \leq 0.05$)				
Feature	Visor Type	N	Mean	s.d.	None	Fthin	Fthick	Cthin	Cthick
Rifle Compatibility	None	10	6.5	1.3					√
	Flat thin	9	5.8	1.0					
	Flat thick	7	5.1	1.8					
	Curved thin	8	4.0	1.4					
	Curved thick	9	3.3	2.6	√				
Visual Sharpness	None	10	6.3	1.3					
	Flat thin	9	6.0	1.2					
	Flat thick	7	4.7	1.8					
	Curved thin	8	4.0	1.4					
	Curved thick	9	3.8	2.4					
Visual Distortion	None	10	6.4	1.3					√
	Flat thin	9	5.8	1.0					√
	Flat thick	7	5.0	2.0					√
	Curved thin	8	4.0	1.4					
	Curved thick	9	2.3	1.9	√	√	√		
Field of View	None	10	6.6	1.3					
	Flat thin	9	6.3	1.0					
	Flat thick	7	4.1	2.4					
	Curved thin	8	4.5	0.7					
	Curved thick	9	4.0	2.2					
Nausea	None	10	6.7	0.7					√
	Flat thin	9	6.5	0.6					√
	Flat thick	7	6.0	1.4					√
	Curved thin	8	5.5	0.7					
	Curved thick	9	3.5	3.0	√	√	√		
Depth Perception	None	10	6.6	0.8					√
	Flat thin	9	6.3	1.0					√
	Flat thick	7	5.3	1.6					√
	Curved thin	8	4.5	0.7					
	Curved thick	9	2.8	2.9	√	√	√		
Visual Glare/ Haze	None	10	6.6	1.3					
	Flat thin	9	4.8	2.2					
	Flat thick	7	4.0	2.0					
	Curved thin	8	4.5	2.1					
	Curved thick	9	4.5	1.9					
Target Detection (Front)	None	10	6.5	0.8					√
	Flat thin	9	5.8	1.0					
	Flat thick	7	5.6	1.4					
	Curved thin	8	5.5	0.7					
	Curved thick	9	4.0	2.6	√				
Target Detection (Sides)	None	10	6.3	1.3					
	Flat thin	9	5.3	1.7					
	Flat thick	7	3.7	1.9					
	Curved thin	8	4.5	0.7					
	Curved thick	9	4.0	2.2					

Jungle Lane Descriptive Data Summary

Descriptive Data					Significant Differences ($p \leq 0.05$)				
Feature	Visor Type	N	Mean	s.d.	None	Fthin	Fthick	Cthin	Cthick
Reaction to Enemy Target	None	10	6.4	1.3					
	Flat thin	9	6.0	1.2					
	Flat thick	7	4.9	1.2					
	Curved thin	8	5.0	1.4					
	Curved thick	9	4.5	2.1					
Firing Postures	None	10	6.5	1.3					
	Flat thin	9	6.0	1.2					
	Flat thick	7	5.3	1.8					
	Curved thin	8	4.5	2.1					
	Curved thick	9	3.5	2.4					
Overall Rating	None	10	6.5	1.3					√
	Flat thin	9	5.8	1.0					√
	Flat thick	7	4.6	1.1					
	Curved thin	8	4.5	0.7					
	Curved thick	9	2.8	2.2	√	√			

Appendix 5 to Annex E: Pugil Fighting Descriptive Data Summary

Descriptive Data					Significant Differences ($p \leq 0.05$)			
Feature	Visor Type	N	Mean	s.d.	Fthin	Fthick	Cthin	Cthick
Balance on Head	Flat thin	12	3.5	1.8				
	Flat thick	8	2.9	1.5				
	Curved thin	10	4.4	2.1				
	Curved thick	6	3.2	1.5				
Stability on Helmet	Flat thin	12	2.7	1.8				
	Flat thick	8	1.8	1.0				
	Curved thin	10	3.9	2.4				
	Curved thick	6	2.7	1.6				
Range of Head Movement	Flat thin	12	3.2	2.1				
	Flat thick	8	3.6	1.3				
	Curved thin	10	4.5	1.9				
	Curved thick	6	3.7	1.8				
Speed of Head Movement	Flat thin	12	2.9	2.0				
	Flat thick	8	3.0	0.9				
	Curved thin	10	4.3	2.1				
	Curved thick	6	3.5	1.4				
Ventilation/ Fogging	Flat thin	12	3.8	1.6				
	Flat thick	8	2.5	1.2				
	Curved thin	10	3.9	1.7				
	Curved thick	6	3.3	1.4				
Thermal Load	Flat thin	12	3.1	2.0				
	Flat thick	8	2.6	1.2				
	Curved thin	10	3.3	1.9				
	Curved thick	6	2.8	1.5				
Blunt Trauma Protection	Flat thin	12	2.6	1.4				
	Flat thick	8	2.4	1.7				
	Curved thin	10	3.0	2.2				
	Curved thick	6	3.5	1.9				
Visual Sharpness	Flat thin	12	3.6	1.7				
	Flat thick	8	3.8	1.4				
	Curved thin	10	3.9	1.5				
	Curved thick	6	2.5	1.4				
Field of View	Flat thin	12	3.2	1.9				
	Flat thick	8	3.5	1.9				
	Curved thin	10	4.0	1.7				
	Curved thick	6	3.5	1.4				
Nausea	Flat thin	12	4.1	1.8				
	Flat thick	8	4.6	2.4				
	Curved thin	10	4.7	2.2				
	Curved thick	6	3.3	2.4				
Depth Perception	Flat thin	12	3.3	2.0				
	Flat thick	8	4.0	2.1				
	Curved thin	10	3.6	1.6				
	Curved thick	6	2.7	1.4				
Riot Control Tasks	Flat thin	11	2.5	1.8				
	Flat thick	8	2.0	1.2				
	Curved thin	9	2.7	1.6				
	Curved thick	6	2.2	1.2				
Overall Rating	Flat thin	12	2.8	1.6				
	Flat thick	8	1.9	0.8				
	Curved thin	10	3.2	1.9				
	Curved thick	6	2.3	1.8				

Appendix 5 to
Annex E:
Pugil Fighting Descriptive Data Summary

Descriptive Data					Significant Differences ($p \leq 0.05$)			
Feature	Visor Type	N	Mean	s.d.	Fthin	Fthick	Cthin	Cthick
Weight on Head	Flat thin	18	4.8	1.4		√		√
	Flat thick	16	2.6	1.5	√		√	
	Curved thin	15	5.5	1.4		√		√
	Curved thick	18	2.8	1.7	√		√	
Eye Fatigue/ Headaches	Flat thin	18	4.9	1.5		√		√
	Flat thick	16	3.1	1.6	√		√	
	Curved thin	15	5.3	1.3		√		√
	Curved thick	18	2.7	2.0	√		√	
Neck Discomfort	Flat thin	18	4.9	1.4		√		√
	Flat thick	16	3.1	1.6	√		√	
	Curved thin	15	5.5	1.4		√		√
	Curved thick	18	3.1	1.9	√		√	
Balance on Head	Flat thin	18	4.8	1.3		√		√
	Flat thick	16	2.4	1.7	√		√	
	Curved thin	15	5.3	1.4		√		√
	Curved thick	18	2.8	2.0	√		√	
Stability on Helmet	Flat thin	18	4.3	1.4		√		√
	Flat thick	16	2.9	2.1	√		√	
	Curved thin	15	5.5	1.5		√		√
	Curved thick	18	2.9	2.0	√		√	
Range of Head Movement	Flat thin	18	4.4	1.6				
	Flat thick	16	3.6	1.8			√	
	Curved thin	15	5.0	1.9		√		√
	Curved thick	18	3.3	2.0			√	
Paintball Gun Compatibility	Flat thin	18	4.1	1.8				
	Flat thick	16	2.8	1.5			√	
	Curved thin	15	4.9	2.0		√		√
	Curved thick	18	2.8	2.1			√	
Ventilation/ Fogging	Flat thin	18	3.4	1.5				
	Flat thick	16	2.3	1.2			√	
	Curved thin	15	4.1	2.1		√		√
	Curved thick	18	2.3	1.4			√	
Thermal Load	Flat thin	18	3.8	1.4		√		√
	Flat thick	16	2.1	1.1	√		√	
	Curved thin	15	3.9	1.8		√		√
	Curved thick	18	2.4	1.4	√		√	
Ballistic Protection	Flat thin	18	5.2	1.1				√
	Flat thick	16	4.4	2.0				
	Curved thin	15	5.1	1.6				
	Curved thick	18	3.9	2.0	√			
Sand/Dust Protection	Flat thin	18	5.2	1.1		√		√
	Flat thick	16	3.9	1.8	√			
	Curved thin	15	5.0	1.6				√
	Curved thick	18	3.7	2.2	√		√	
Sharp Objects (Branches, etc)	Flat thin	18	5.4	1.1				√
	Flat thick	16	4.3	2.0				
	Curved thin	15	5.3	1.2				√
	Curved thick	18	3.9	2.3	√		√	

Appendix 5 to Annex E: Pugil Fighting Descriptive Data Summary

Descriptive Data					Significant Differences (p ≤ 0.05)			
Feature	Visor Type	N	Mean	s.d.	Fthin	Fthick	Cthin	Cthick
Visual Sharpness	Flat thin	18	4.2	1.6		√		√
	Flat thick	16	2.6	1.4	√		√	
	Curved thin	15	4.2	1.7		√		√
	Curved thick	18	2.3	1.4	√		√	
Visual Distortion	Flat thin	18	4.2	1.6		√		√
	Flat thick	16	2.1	1.2	√		√	
	Curved thin	15	4.2	1.9		√		√
	Curved thick	18	2.1	1.4	√		√	
Field of View	Flat thin	18	4.0	1.7		√		
	Flat thick	16	2.6	1.7	√		√	
	Curved thin	15	5.0	1.5		√		√
	Curved thick	18	3.2	2.1			√	
Nausea	Flat thin	18	5.4	1.2		√		√
	Flat thick	16	3.8	2.1	√		√	
	Curved thin	15	5.7	1.2		√		√
	Curved thick	18	3.4	2.4	√		√	
Depth Perception	Flat thin	18	4.8	1.5		√		√
	Flat thick	16	2.7	1.7	√		√	
	Curved thin	15	4.5	1.8		√		√
	Curved thick	18	2.2	1.6	√		√	
Visual Glare/ Haze	Flat thin	18	3.3	1.8		√	√	√
	Flat thick	16	1.9	0.9	√		√	√
	Curved thin	15	3.7	1.8	√	√		√
	Curved thick	18	2.3	1.7	√	√	√	
Camouflage/ Detectability	Flat thin	18	3.0	1.7				
	Flat thick	16	2.1	1.2				
	Curved thin	15	2.9	1.4				
	Curved thick	18	2.1	1.5				
Target Detection (Front)	Flat thin	18	4.8	1.5		√		√
	Flat thick	16	3.3	1.5	√			
	Curved thin	15	4.2	2.1				
	Curved thick	18	3.1	2.0	√			
Target Detection (Sides)	Flat thin	18	3.7	1.7		√		
	Flat thick	16	2.3	1.2	√		√	
	Curved thin	15	4.0	2.1		√		
	Curved thick	18	2.8	1.7				
Obstacle Traverse	Flat thin	18	4.4	1.4		√		√
	Flat thick	16	3.0	1.8	√		√	
	Curved thin	15	4.3	2.0		√		√
	Curved thick	18	3.1	2.2	√		√	

Appendix 5 to
Annex E:
Pugil Fighting Descriptive Data Summary

Descriptive Data					Significant Differences ($p \leq 0.05$)			
Feature	Visor Type	N	Mean	s.d.	Fthin	Fthick	Cthin	Cthick
FIBUA Warfare	Flat thin	18	4.0	1.4		√		
	Flat thick	16	2.6	1.5	√		√	
	Curved thin	15	4.1	1.6		√		
	Curved thick	18	2.9	2.0				
Section Attacks	Flat thin	18	4.1	1.4		√		√
	Flat thick	16	2.6	1.5	√		√	
	Curved thin	15	3.8	1.4		√		√
	Curved thick	18	2.7	1.7	√		√	
Overall Rating	Flat thin	18	4.3	1.1		√		√
	Flat thick	16	2.3	1.1	√		√	
	Curved thin	15	4.1	2.0		√		√
	Curved thick	18	2.6	1.5	√		√	

Appendix 5 to
Annex E:
Pugil Fighting Descriptive Data Summary

Descriptive Data					Significant Differences ($p \leq 0.05$)			
Feature	Visor Type	N	Mean	s.d.	Fthin	Fthick	Cthin	Cthick
Weight on Head	Flat thin	10	4.1	2.1				
	Flat thick	9	3.0	1.3				
	Curved thin	8	4.9	1.8				
	Curved thick	9	3.0	1.7				
Eye Fatigue/ Headaches	Flat thin	10	2.7	1.4				
	Flat thick	9	3.6	2.1				
	Curved thin	8	3.3	1.6				
	Curved thick	9	3.7	1.7				
Neck Discomfort	Flat thin	10	4.1	2.1				
	Flat thick	9	3.8	1.3				
	Curved thin	8	4.9	2.0				
	Curved thick	9	3.4	1.5				
Balance on Head	Flat thin	10	4.1	2.1		√		
	Flat thick	9	2.4	1.3	√		√	
	Curved thin	8	5.0	2.1		√		√
	Curved thick	9	2.9	1.8			√	
Stability on Helmet	Flat thin	10	3.7	2.1				
	Flat thick	9	3.1	1.6				
	Curved thin	8	4.5	2.1				
	Curved thick	9	3.3	1.7				
Range of Head Movement	Flat thin	10	4.1	2.2				
	Flat thick	9	3.6	1.8				
	Curved thin	8	5.1	2.1				
	Curved thick	9	3.7	1.7				
Rifle Compatibility	Flat thin	10	3.1	1.5				
	Flat thick	9	2.8	1.8				
	Curved thin	8	3.3	2.0				
	Curved thick	9	2.9	1.4				
Ventilation/ Fogging	Flat thin	9	2.3	1.2				
	Flat thick	9	2.4	1.6				
	Curved thin	8	3.0	1.7				
	Curved thick	9	2.9	1.5				
Thermal Load	Flat thin	9	2.7	1.2				
	Flat thick	9	2.4	1.5				
	Curved thin	8	3.1	1.6				
	Curved thick	9	2.3	1.3				
Visual Sharpness	Flat thin	9	1.8	1.4				
	Flat thick	9	1.3	0.5				
	Curved thin	8	2.0	1.4				
	Curved thick	9	1.4	0.5				
Visual Distortion	Flat thin	9	1.6	0.9				
	Flat thick	9	1.3	0.5				
	Curved thin	8	1.9	1.4				
	Curved thick	9	1.4	0.7				
Field of View	Flat thin	9	2.9	2.0				
	Flat thick	9	1.9	0.9				
	Curved thin	8	3.3	2.4				
	Curved thick	9	1.8	0.8				

Appendix 5 to
Annex E:
Pugil Fighting Descriptive Data Summary

Descriptive Data					Significant Differences ($p \leq 0.05$)			
Feature	Visor Type	N	Mean	s.d.	Fthin	Fthick	Cthin	Cthick
Nausea	Flat thin	9	4.7	2.2				
	Flat thick	9	4.3	2.6				
	Curved thin	8	4.9	2.3				
	Curved thick	9	4.2	2.2				
Depth Perception	Flat thin	9	2.1	1.5				
	Flat thick	9	1.9	1.1				
	Curved thin	8	2.6	2.1				
	Curved thick	9	1.7	0.9				
Visual Glare/ Haze	Flat thin	9	1.4	0.7				
	Flat thick	9	1.9	1.2				
	Curved thin	8	2.1	1.8				
	Curved thick	9	1.7	1.1				
Ghost Images	Flat thin	9	1.9	1.2				
	Flat thick	9	2.8	2.1				
	Curved thin	8	2.3	1.6				
	Curved thick	9	1.6	0.9				
Double Vision	Flat thin	9	3.6	1.9				
	Flat thick	9	2.9	2.2				
	Curved thin	8	3.8	2.0				
	Curved thick	9	2.0	1.5				
Camouflage/ Detectability	Flat thin	9	2.2	1.5				
	Flat thick	9	1.3	0.5				
	Curved thin	8	2.5	1.9				
	Curved thick	9	1.4	0.5				
Target Detection (Front)	Flat thin	8	1.6	0.7				
	Flat thick	8	1.6	1.1				
	Curved thin	7	2.1	1.5				
	Curved thick	8	1.5	0.5				
Target Detection (Sides)	Flat thin	8	2.0	1.8				
	Flat thick	8	1.1	0.4				
	Curved thin	7	2.0	1.5				
	Curved thick	8	1.5	0.5				
Fire and Movement	Flat thin	8	2.0	1.3				
	Flat thick	8	1.9	1.1				
	Curved thin	7	2.3	1.9				
	Curved thick	8	2.3	1.3				
Overall Rating	Flat thin	8	2.0	1.4				
	Flat thick	8	1.6	0.7				
	Curved thin	7	2.1	1.7				
	Curved thick	8	1.8	0.7				

ANNEX F - VEHICLE COMPATIBILTY

1. Introduction

While providing ballistic protection to the dismounted soldier, the visor systems under investigation offer similar protection to drivers and commanders of vehicles during "Hatches Up" operation. The visors, however, must not interfere with driving tasks and must allow for the use of additional goggles to provide protection from sand, wind and dust. The additional weight of the visor and attachment system must not contribute to excessive fatigue and physical discomfort or detract significantly from driver performance.

2. Method

Participant driving performance was evaluated using a forward slalom course. Participants were required to drive a course bounded by flag posted markers positioned at each of the corners of the course. Participants were required to rate their performance in vehicle operation in each visor condition using a Task Questionnaire. HF observers evaluated participants during vehicle operation for any postural, range of movement, crewstation obstruction, and vision effects, and noted driving accuracy in terms of the number of slalom course markers hit by the vehicle.

All visor conditions were evaluated for compatibility with the AVGP (Figures F-1 and F-2, below). The order of visor conditions was balanced for each participant.

Figure F-1: AVGP (Grizzly) on driving course.

Figure F-2: AVGP (Grizzly) on driving course.

3. Results

Results for the driving task questionnaire are summarized below in Figures F-3, F-4, and F-5. Appendix 1 to this annex includes a tabular listing of all descriptive data obtained from the task questionnaire. Significant differences ($p \leq 0.05$) are indicated between visor conditions.

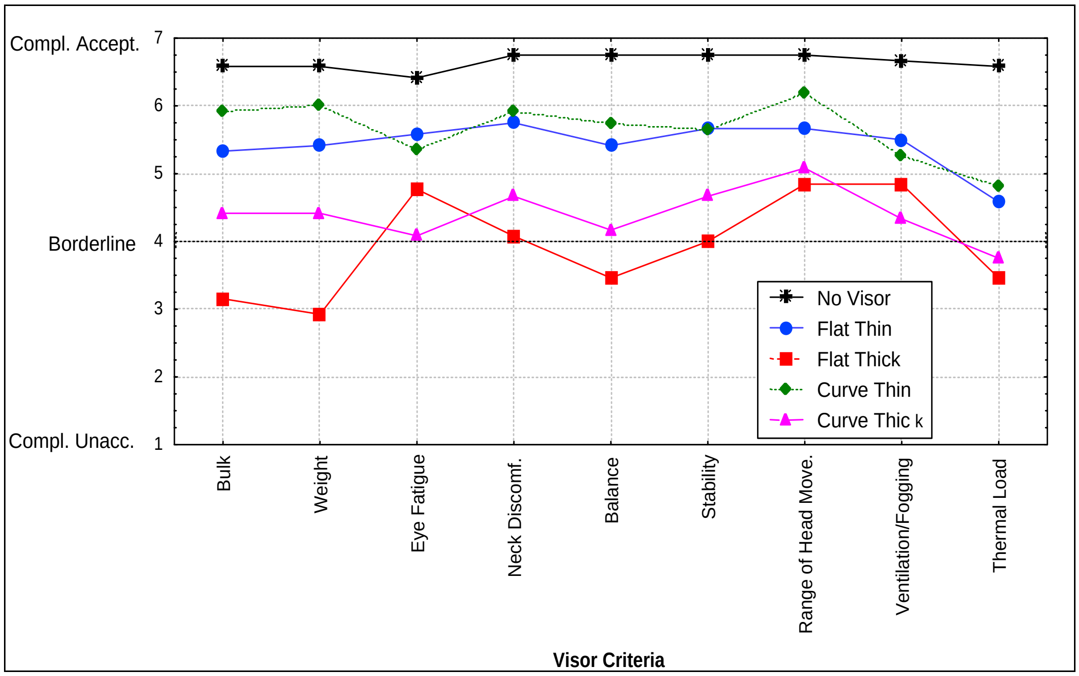


Figure F-3: Driving Task Questionnaire Results (1 of 3)

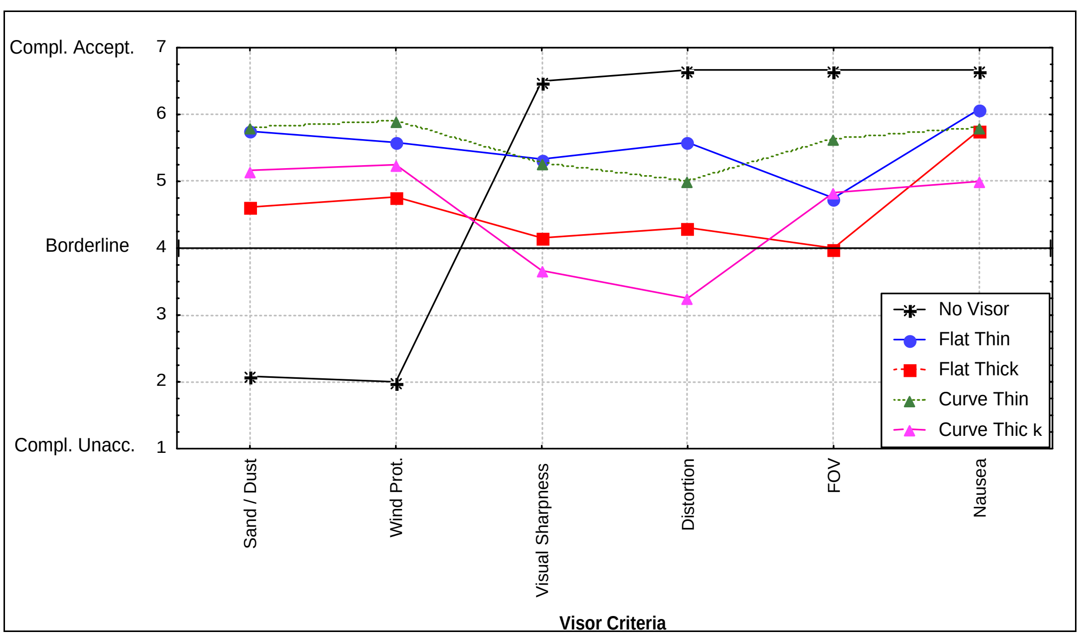


Figure F-4: Driving Task Questionnaire Results (2 of 3)

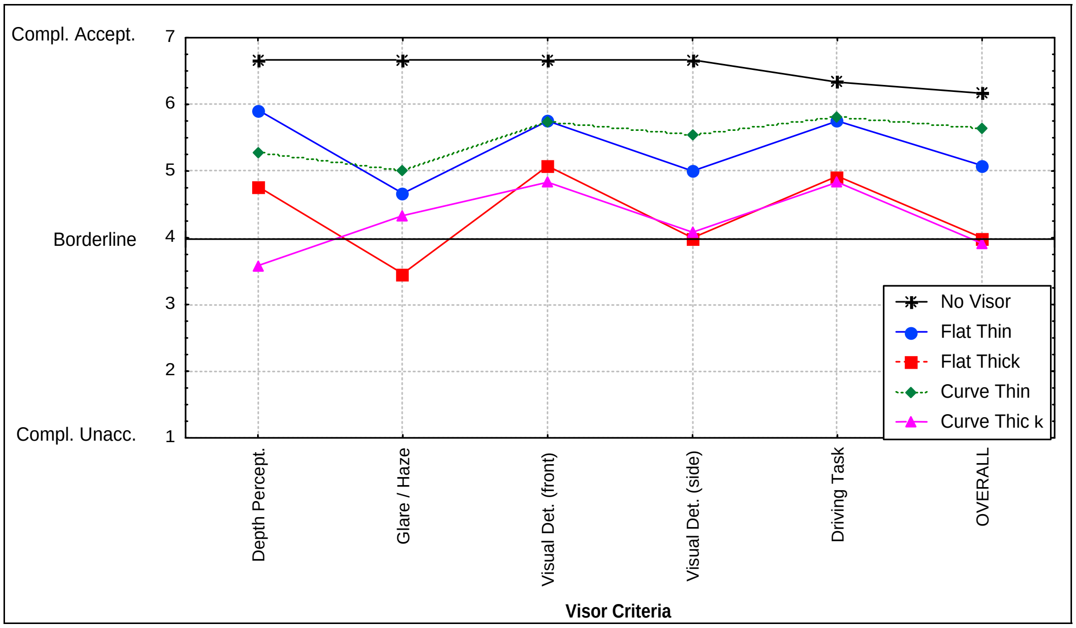


Figure F-5: Driving Task Quesitonnaire Results (3 of 3)

3.1 Overall:

All visors were generally rated as borderline or better for vehicle driving and were rated significantly more favourably for Sand/Dust and Wind Protection than the no visor baseline. Thin visors were rated more favourably than thick visors.

3.2 Thin Visors:

Both the flat and curved thin visors were rated as acceptable for all features assessed and were typically rated higher for most features than both the curved and flat thick visors. The flat thin and curved thin visors were similarly rated for most of the features assessed.

3.3 Thick Visors:

The flat thick visor was rated as unacceptable for the following features:

- bulk, weight, balance, thermal load, and glare/haze.

The curved thick visor was rated as unacceptable for the following features:

- thermal load, visual sharpness, distortion and depth perception.

4. Discussion

Overall, the visors assessed in this trial were preferred over the no-visor condition for ballistic and sand/wind/dust protection and were generally rated as suitable for driving tasks.

The thin visors, both flat and curved, were similarly rated as acceptable for all features assessed and were typically rated more favourably for most features than both the curved and flat thick visors. The flat and curved thick visors did not fair as well. Since driving is predominantly a visual task, anything that detracts from a driver's visual performance will be problematic. This was the case with the thick visor systems studied.

Participants expressed dissatisfaction with the thick visors due to reduced visual performance associated with glare/haze, distortion and reduced depth perception. The curved thick visor was considered worse than the flat thick visor for these visual deficiencies. The thick visors, while affording greater ballistic protection than the thin visors, were also heavier and bulkier. The increased load forces of the thick visors during vehicle movement was cited as contributing to neck fatigue and discomfort, which could lead to reduced driver attention and performance during prolonged driving activities.

Appendix 1 to Annex F: Vehicle Compatibility Questionnaire

Descriptive Data					Significant Differences ($p \leq 0.05$)				
Feature	Visor Type	N	Mean	s.d.	None	Fthin	Fthick	Cthin	Cthick
Bulk on Head	None	12	6.58			√	√		√
	Flat thin	12	5.33		√		√		
	Flat thick	12	3.15		√	√		√	√
	Curved thin	12	5.91				√		√
	Curved thick	12	4.42		√		√	√	
Weight on Head	None	12	6.58				√		√
	Flat thin	12	5.42				√		
	Flat thick	12	2.92		√	√		√	√
	Curved thin	12	6.00				√		√
	Curved thick	12	4.42		√		√	√	
Eye Fatigue/ Headaches	None	12	6.42				√		√
	Flat thin	12	5.58						√
	Flat thick	12	4.77		√				
	Curved thin	12	5.36						
	Curved thick	12	4.08		√	√			
Neck Discomfort	None	12	6.75				√		√
	Flat thin	12	5.75				√		
	Flat thick	12	4.08		√	√		√	
	Curved thin	12	5.91				√		√
	Curved thick	12	4.67		√			√	
Balance on Head	None	12	6.75			√	√		√
	Flat thin	12	5.42		√		√		√
	Flat thick	12	3.46		√	√		√	
	Curved thin	12	5.73				√		√
	Curved thick	12	4.17		√	√		√	
Stability on Helmet	None	12	6.75				√		√
	Flat thin	12	5.67				√		
	Flat thick	12	4.00		√	√		√	
	Curved thin	12	5.64				√		
	Curved thick	12	4.67		√				
Range of Head Movement	None	12	6.75			√	√		√
	Flat thin	12	5.67		√				
	Flat thick	12	4.85		√			√	
	Curved thin	12	6.19				√		√
	Curved thick	12	5.08		√			√	
Ventilation/ Fogging	None	12	6.67			√	√	√	√
	Flat thin	12	5.50		√				√
	Flat thick	12	4.85		√				
	Curved thin	12	5.27		√				
	Curved thick	12	4.33		√	√			
Thermal Load	None	12	6.58			√	√	√	√
	Flat thin	12	4.58		√				
	Flat thick	12	3.46		√			√	
	Curved thin	12	4.82		√		√		
	Curved thick	12	3.75		√				
Sand/Dust Protection	None	12	2.08			√	√	√	√
	Flat thin	12	5.75		√				
	Flat thick	12	4.62		√				
	Curved thin	12	5.82		√				
	Curved thick	12	5.17		√				

Descriptive Data					Significant Differences (p ≤ 0.05)				
Feature	Visor Type	N	Mean	s.d.	None	Fthin	Fthick	Cthin	Cthick
Wind Protection	None	12	2.00			√	√	√	√
	Flat thin	12	5.58		√				
	Flat thick	12	4.77		√				
	Curved thin	12	5.91		√				
	Curved thick	12	5.25		√				
Visual Sharpness	None	12	6.50			√	√	√	√
	Flat thin	12	5.33		√				√
	Flat thick	12	4.15		√				
	Curved thin	12	5.27		√				√
	Curved thick	12	3.67		√	√		√	
Visual Distortion	None	12	6.67			√	√	√	√
	Flat thin	12	5.58		√		√		√
	Flat thick	12	4.31		√	√			
	Curved thin	12	5.00		√				√
	Curved thick	12	3.25		√	√		√	
Field of View	None	12	6.67			√	√		√
	Flat thin	12	4.75		√				
	Flat thick	12	4.00		√			√	
	Curved thin	12	5.64				√		
	Curved thick	12	4.83		√				
Nausea	None	12	6.67						√
	Flat thin	12	6.08						
	Flat thick	12	5.77						
	Curved thin	12	5.82						
	Curved thick	12	5.00		√				
Depth Perception	None	12	6.67				√	√	√
	Flat thin	12	5.92						√
	Flat thick	12	4.77		√				
	Curved thin	12	5.27		√				√
	Curved thick	12	3.58		√	√		√	
Visual Glare/Haze	None	12	6.67			√	√	√	√
	Flat thin	12	4.67		√				
	Flat thick	12	3.46		√			√	
	Curved thin	12	5.00		√		√		
	Curved thick	12	4.33		√				
Object Detection (Front)	None	12	6.67				√		√
	Flat thin	12	5.75						
	Flat thick	12	5.08		√				
	Curved thin	12	5.73						
	Curved thick	12	4.83		√				
Object Detection (Sides)	None	12	6.67			√	√	√	√
	Flat thin	12	5.00		√				
	Flat thick	12	4.00		√			√	
	Curved thin	12	5.55		√		√		√
	Curved thick	12	4.08		√			√	
Driving Tasks	None	12	6.33				√		√
	Flat thin	12	5.75						
	Flat thick	12	4.92		√				
	Curved thin	12	5.82						
	Curved thick	12	4.83		√				

Descriptive Data					Significant Differences (p ≤ 0.05)				
Feature	Visor Type	N	Mean	s.d.	None	Fthin	Fthick	Cthin	Cthick
Overall Ratings	None	12	6.17			√	√		√
	Flat thin	12	5.08		√		√		√
	Flat thick	12	4.00		√	√		√	
	Curved thin	12	5.64				√		√
	Curved thick	12	3.92		√	√		√	

ANNEX G - EXIT FOCUS GROUP

1. Introduction

To assess user acceptance, participants were required to rate the acceptability of each visor condition, for the complete range of human factors criteria evaluated during this trial, using both questionnaires and focus group discussions. These final series of questionnaires and focus groups sought to capture the accumulated opinions of participants, having completed all tests and military tasks during the trial.

2. Method

Participants were first required to rate the importance of various visor criteria, based on their systematic experience gained during the trial, for designing and selecting a general purpose military visor. An Exit Questionnaire was completed, requiring participants to provide their final conclusive ratings of each visor condition for all human factors criteria evaluated during this trial. Finally, participants were required to rate the functionality and durability of various features of each visor design. Following the completion of all questionnaires, a focus group discussion was held.

3. Results

Results for each assessment are described below.

3.1 Criteria of Importance:

Results from the criteria of importance questionnaire are summarized below in Figure G-1. The order of the criteria listed reflects the degree of importance assigned by the participants (i.e. highest importance at the top of the list).

Overall, weapons compatibility was rated as the most important feature of any visor. The next most important criteria included:

- visual performance (i.e. depth perception, visual distortion, field of view, eye fatigue, and visual sharpness);
- target detection (i.e. target detection to the front and sides);
- ventilation/fogging, thermal load, glare/haze;
- detectability by the enemy; and
- Battle task performance (i.e. Section attack, FIBUA, night patrol, obstacle traverse).

Participants rated the following criteria as having the lowest importance:

- visor stowage;
- appearance;
- eyewear and clothing compatibility; and
- minor repairs.

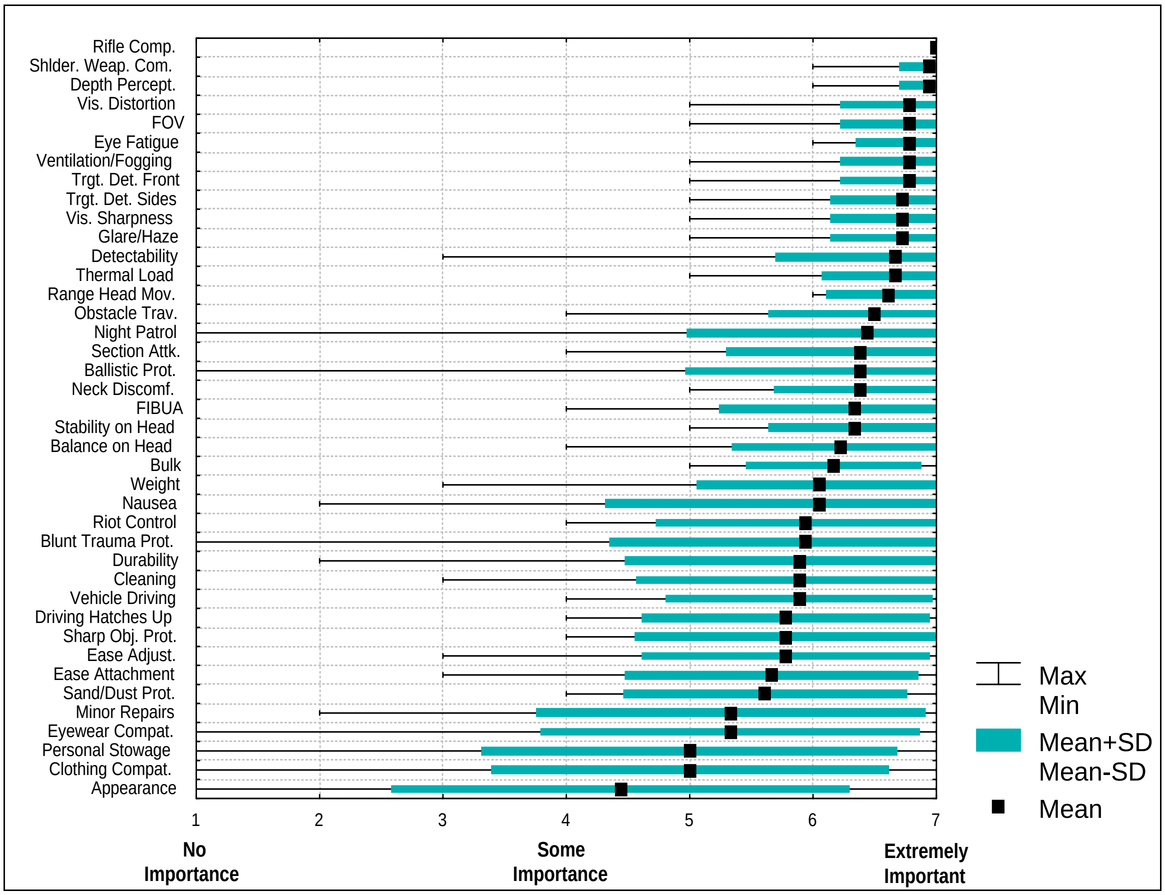


Figure G-1: Importance Criteria

3.2 Exit Questionnaire

Results from the exit questionnaire are presented in the following blocks:

3.2.1 Functionality and Physical Demands;

3.2.2 Compatibility and Thermal Demands;

3.2.3 Maintainability and Protection;

3.2.4 Vision Effects and Detectability; and

3.2.5 Task Demands and Overall Rating.

3.2.1 Functionality and Physical Demands:

Exit questionnaire data relating to visor function and physical demands are summarized below in Figure G-2.

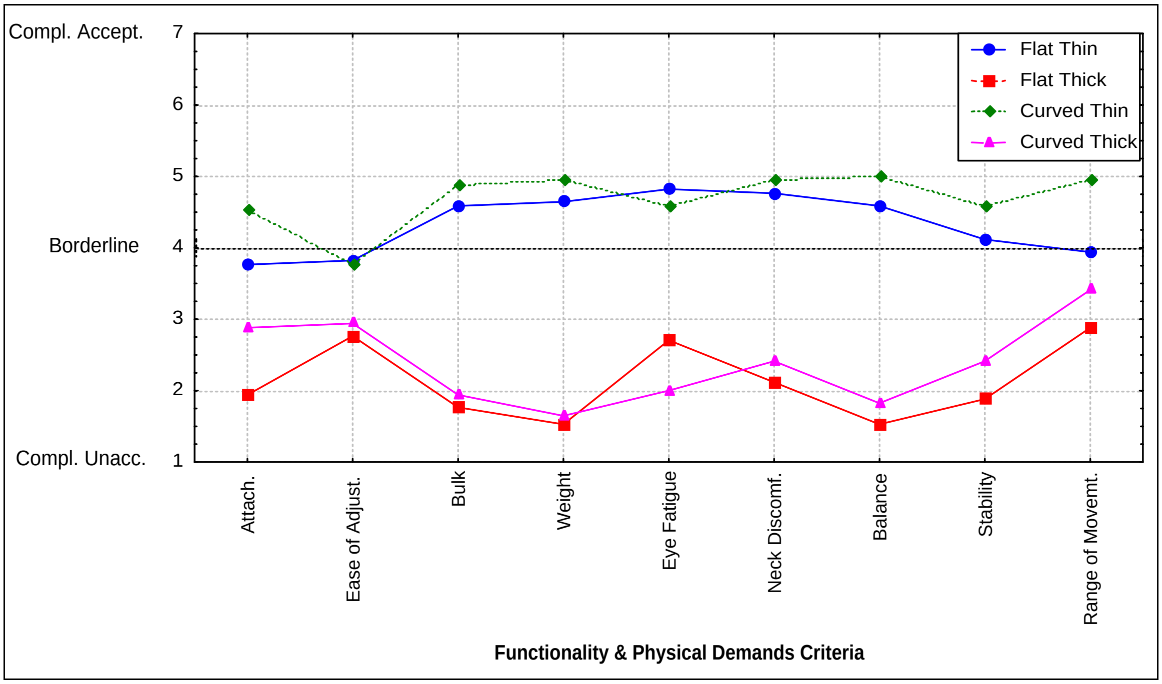


Figure G-2: Functionality and Physical Demands

The thick visors (both flat and curved) were rated as unacceptable for all criteria assessed in this section. With the exception of ease of adjustment, the curved thin visor was rated as acceptable. The flat thin visor was rated as acceptable for all criteria in this section with the exception of attachment, ease of adjustment and range of movement. For most criteria, thin visors were rated significantly more favourably than thick visors.

Ease of adjustment was rated as unacceptable for all visors assessed. The horizontal range of adjustment was cited as the primary reason for the ratings, as most participants could not adjust the visor away from their faces, resulting in some contact on the nose and a lack of room for adequate ventilation.

3.2.2 Compatibility and Thermal Demands:

Exit questionnaire data relating to compatibility and thermal demands criteria are summarized below in Figure G-3.

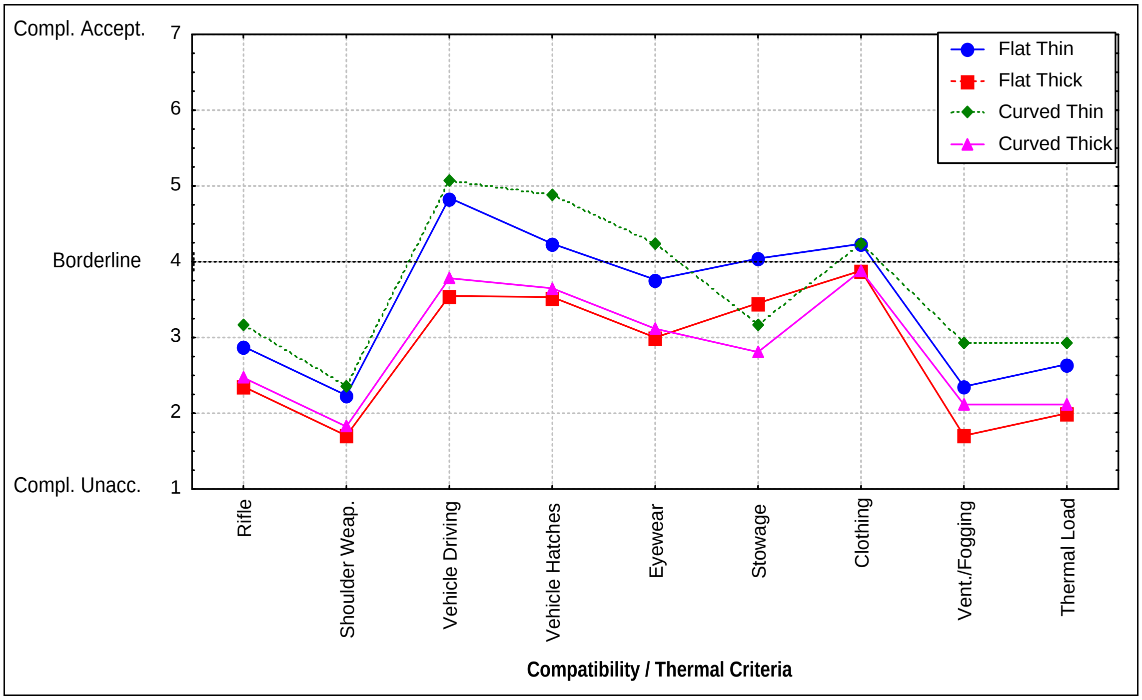


Figure G-3: Compatibility and Thermal Criteria

All visors assessed were rated as unacceptable with respect to the following compatibility and thermal demands criteria:

- Rifle Compatibility;
- Shoulder Fired Weapon Compatibility (M72 and Carl Gustav);
- Ventilation and Fogging; and
- Thermal Load.

Participants noted that all visors tended to fog up on the interior surfaces when performing vigorous physical activity. Regardless of shape (flat or curved) or thickness, participants felt that airflow under the visor was insufficient and contributed to a high thermal burden.

The thick visors (flat and curved) were rated as unacceptable for all criteria assessed in this section. The only significant differences between visor conditions amounted to the Flat Thick visor being rated significantly less favourably than both thin visors.

3.2.3 Maintainability and Protection Criteria:

Exit questionnaire data relating to maintainability and protection criteria are summarized below in Figure G-4.

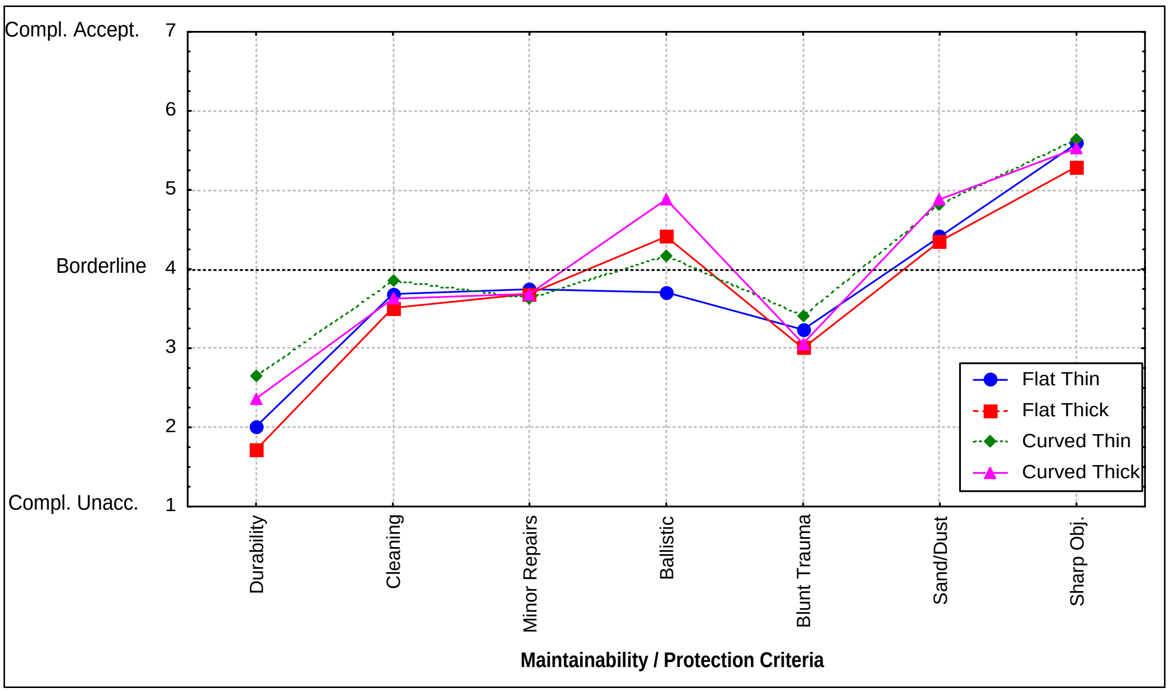


Figure G-4: Maintainability and Protection Criteria

All visors were rated as unacceptable for the following criteria:

- Durability;
- Cleaning;
- Minor repairs; and
- Blunt Trauma Protection.

All visors were rated as acceptable for the following criteria:

- Sand/Dust/Wind Protection; and
- Sharp Object Protection.

There were no differences between visor conditions for maintainability and protection criteria.

3.2.4 Visual Effects and Detection Criteria

Exit questionnaire data relating to visual effects and detectability by the enemy are summarized below in Figure G-5.

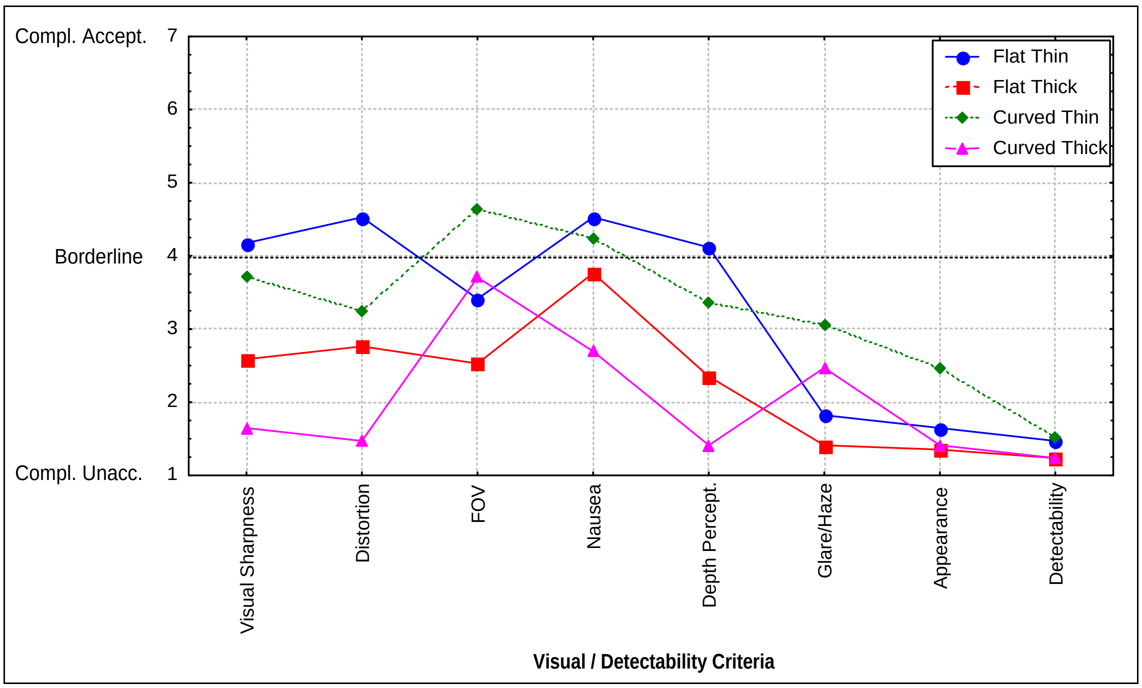


Figure G-5: Visual and Detectability Criteria

The thick visors (both flat and curved) were rated by participants as unnacceptable for all criteria assessed in this section. The thicker visors were rated as unacceptable for visual performance due to perceived reductions in visual sharpness, distortion to the image and a reduction in depth perception. In each case, visual performance was rated worst for the Curved Thick visor, with the exception of field of view. Even the thin visors were only rated between "barely unacceptable and barely acceptable" for visual performance.

Participants noted a very strong concern about the ease with which the enemy could visually detect them when they wore a visor, given the highly reflective surface of a visor.

3.2.5 Task Demands and Overall Rating

Exit questionnaire data relating to task demands and the overall rating are summarized below in Figure G-6.

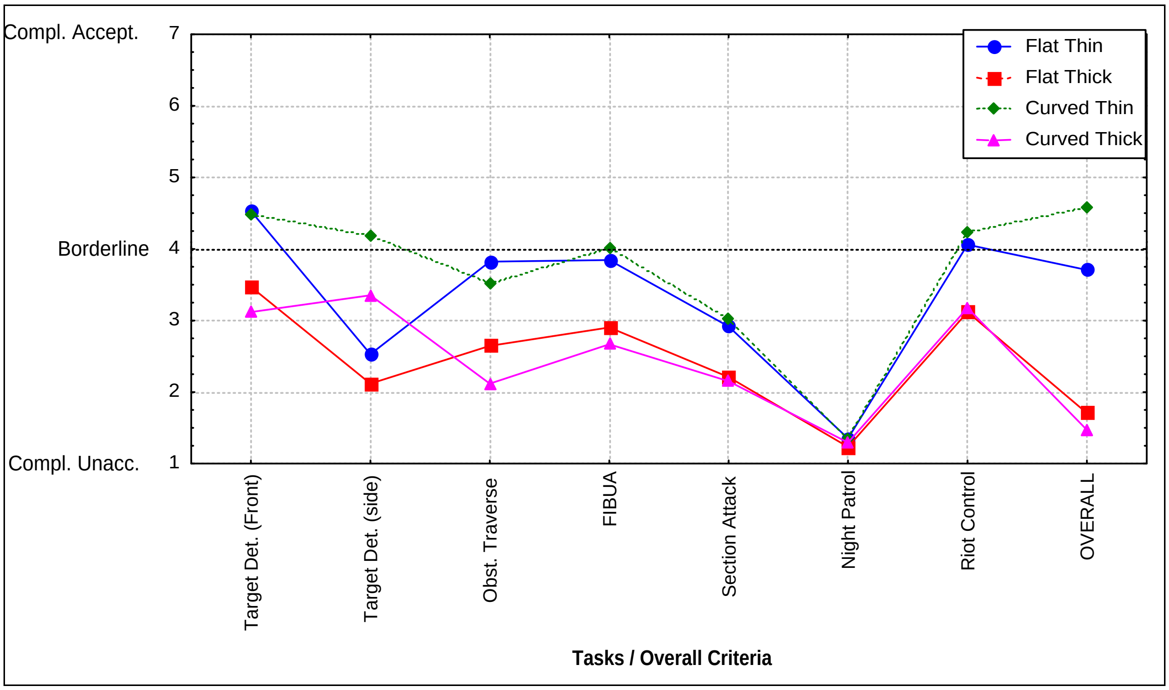


Figure G-6: Tasks and Overall Rating

The thick visors (both flat and curved) were rated as unacceptable for all criteria assessed in this section. Reductions in visual performance and the thermal demands associated with these visors were cited as the primary drivers for the poor task performance ratings. The thin visors were not rated much better. With the exception of night patrols and Section attacks, only the Curved Thin visor achieved "borderline to barely acceptable" ratings.

For the overall rating, the thin visors were rated significantly more favourably than the thick visors. At the end of the trial, only the Curved Thin visor was rated as acceptable overall as a general-purpose visor.

3.3 Feature Questionnaire:

Results from the feature questionnaire are described below for each visor condition.

3.3.1 Curved Thin

Data for the curved thin visor are summarized below in Figure G-7.

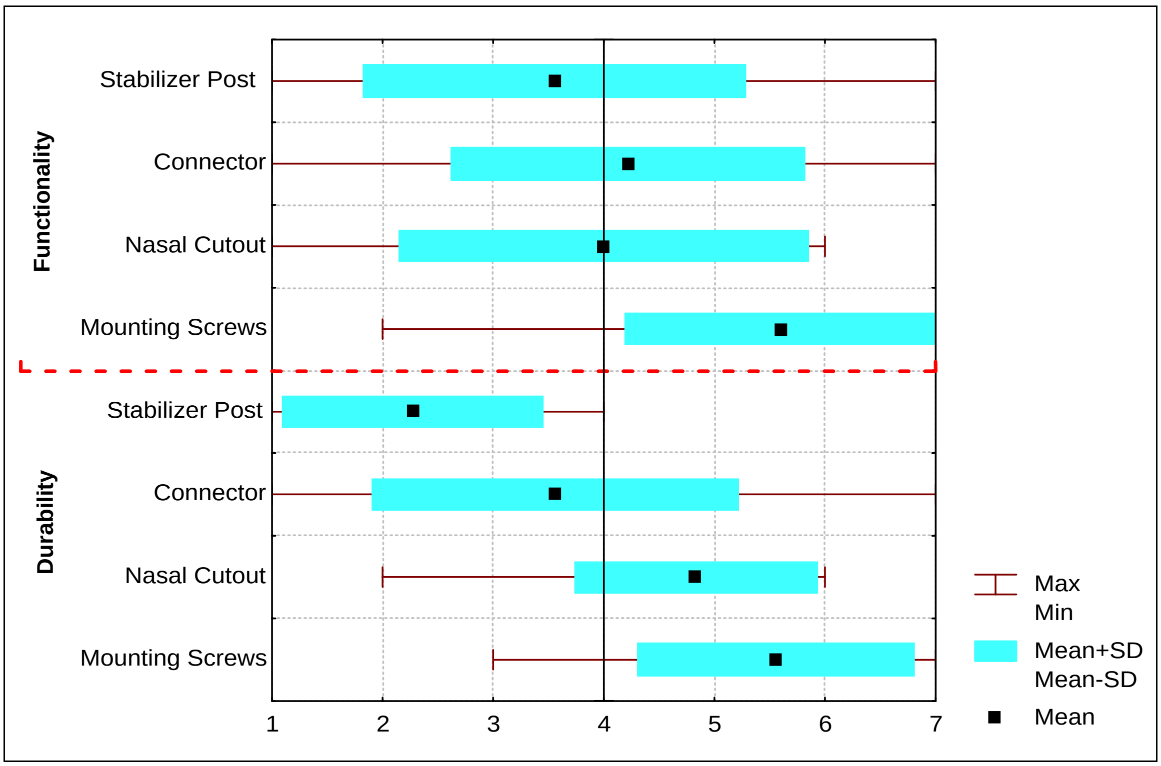


Figure G-7: Curved Thin Visor Features

The stabilizer post of the Fastex-like connector to the visor attachment sub-system on the helmet was rated as unacceptable for both functionality and durability. Participants reported that the post was not effective at stabilizing the connector and tended to break off easily. The connector portion was rated as satisfactory for functionality but was rated as unacceptable for durability due to concerns with the "plastic" material in heavy use and in winter temperatures.

While the nasal cutout was rated as acceptable participants reported that the cutout was not sufficiently large enough for adequate ventilation under the visor, leading to fogging effects.

The mounting screws that hold the visor to the connector were rated as acceptable for both functionality and durability.

3.3.2 Curved Thick:

Data for the curved thick visor are summarized below in Figure G-8.

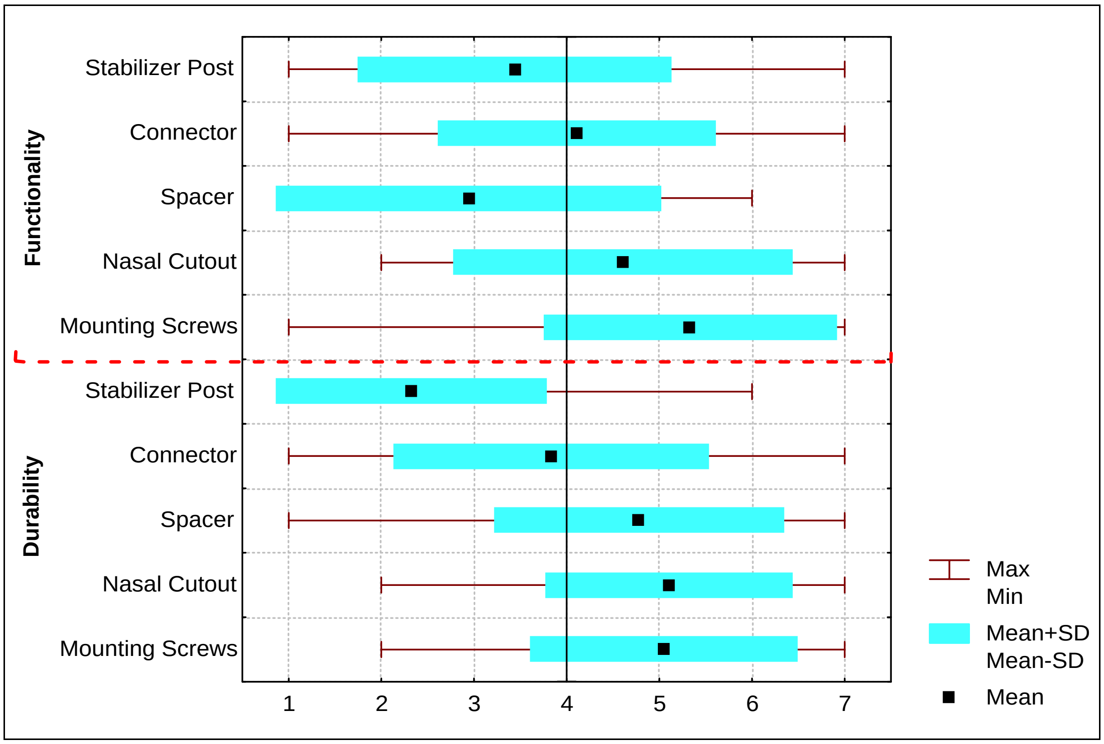


Figure G-8: Curved Thick Visor Features

The stabilizer post was rated as unacceptable for both functionality and durability. Participants noted that the post was prone to damage from ordinary use. The connector was rated as barely acceptable for functionality and barely unacceptable for durability.

The spacer, which comprised a white plastic foam layer between the edges of the two layers of polycarbonate, was rated as unacceptable for functionality and acceptable for durability. The spacer reportedly posed a visual distraction at the limits of peripheral vision (i.e. participants could always see a white frame around the edges of the visor).

The nasal cutout and mounting screws were both rated as acceptable for both functionality and durability.

3.3.3 Flat Thin:

Data for the flat thin visor are summarized in Figure G-9.

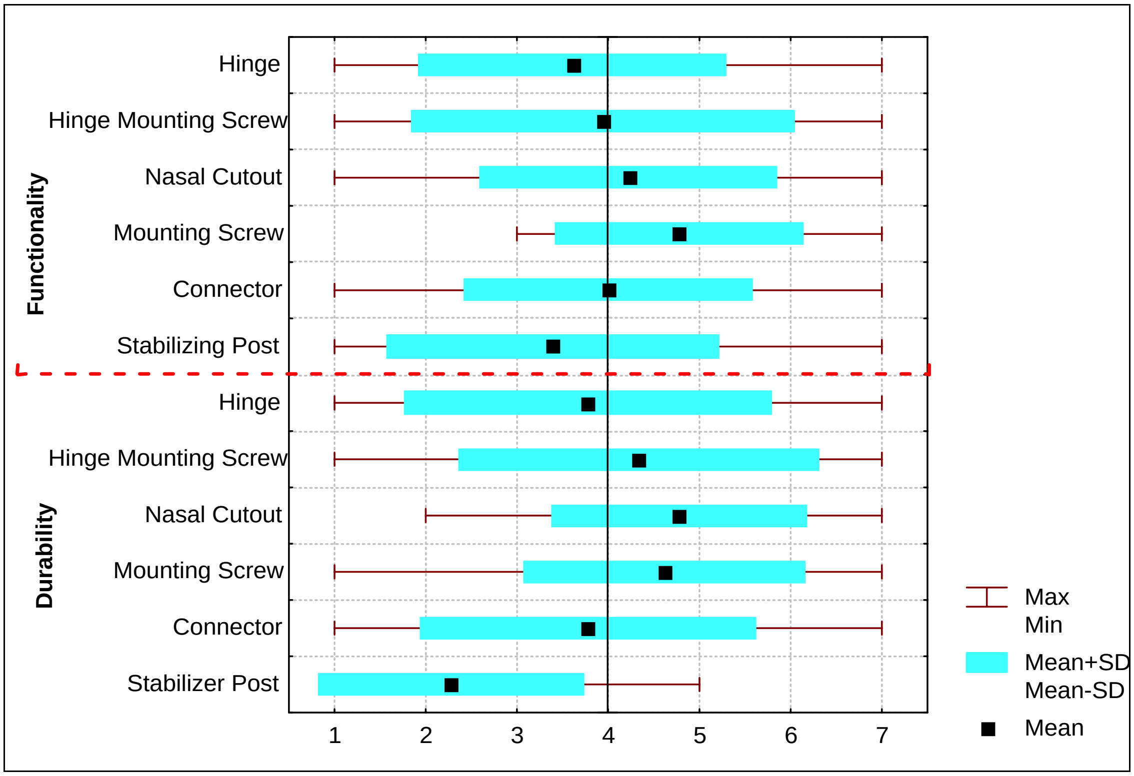


Figure G-9: Flat Thin Visor Feature

The hinge system on the flat thin visor was rated as barely unacceptable for both functionality and durability. Participants reported that the hinge system did not allow the sides of the visor to lie flat, resulting in a bulky stowage profile.

The hinge mounting screws were rated as barely unacceptable for functionality and acceptable for durability.

The nasal cutout and mounting screws were rated as acceptable for both functionality and durability.

The connector portion of the visor was rated as borderline for functionality and barely unacceptable for durability.

The stabilizer post was rated as unacceptable for both functionality and durability. The post was reported as prone to breakage during regular use.

3.3.4 Flat Thick:

Data for the flat thick visor are summarized below in Figure G-10.

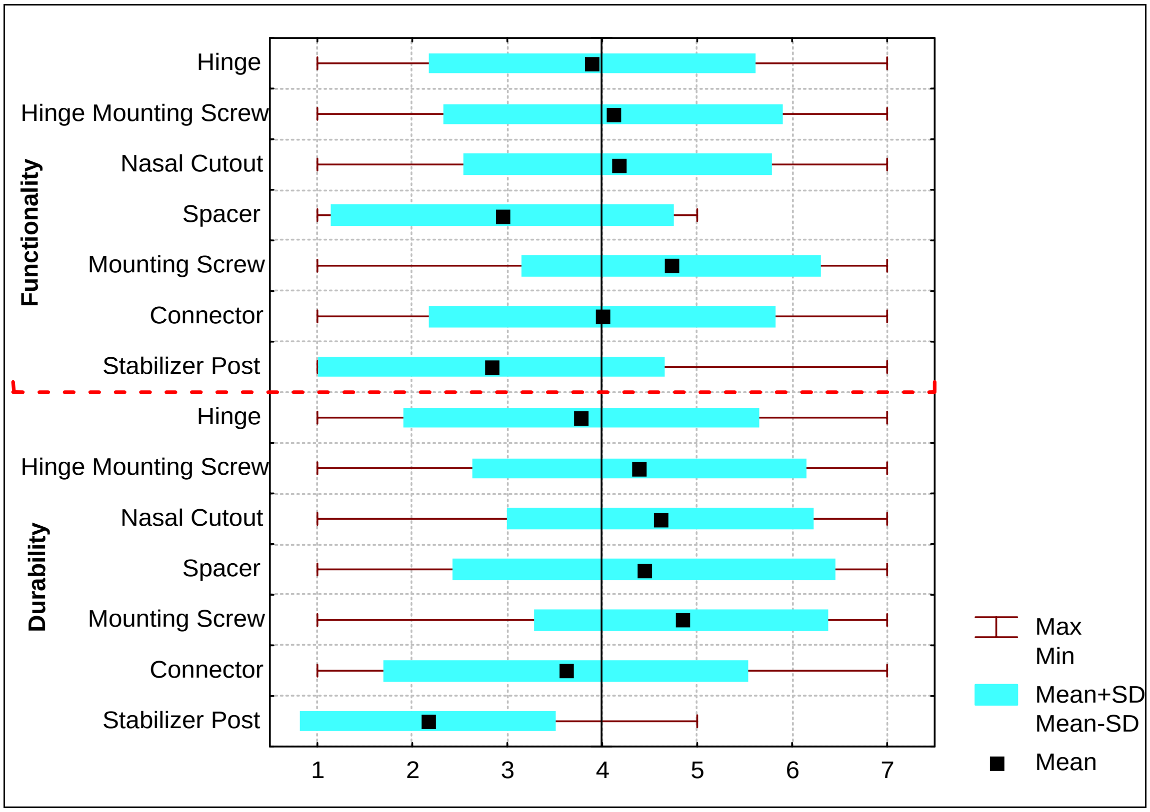


Figure G-10: Flat Thick Visor Feature

The hinge system on the flat thick visor was rated as barely unacceptable for both functionality and durability. Participants reported that the hinge did not allow the sides of the visor to be fully folded against the face piece, and were prone to damage during regular use.

The hinge mounting screw, connector mounting screw, and nasal cutout were rated as acceptable for both functionality and durability.

The spacer was rated as unacceptable for functionality and as acceptable for durability. The spacer was reported as being a visual distraction and reduced field of view at the limits of peripheral vision.

The connector was rated as borderline for functionality and unacceptable for durability. Participants noted that the resin used to make the connector was suspect for damage, especially in cold conditions. The stabilizer post was rated as unacceptable for both functionality and durability. Participants noted that the post did little to stabilize the male end of the buckle and were prone to damage with regular use.

4. Summary

The following section summarizes the results of the Exit focus group discussions and questionnaires.

4.1 Criteria of Importance:

Overall, weapons compatibility was rated as the most important feature of any visor. The next most important criteria included:

- visual performance (i.e. depth perception, visual distortion, field of view, eye fatigue, and visual sharpness);
- target detection (i.e. target detection to the front and sides);
- ventilation/fogging, thermal load, glare/haze;
- detectability by the enemy; and
- Battle task performance (i.e. Section attack, FIBUA, night patrol, obstacle traverse).

Participants rated the following criteria as having the lowest importance:

- visor stowage;
- appearance;
- eyewear and clothing compatibility; and
- minor repairs.

4.2 Visor Features:

For all visor conditions the attachment connection between the visor and the visor attachment sub-system, secured to the helmet, proved problematic. The visor connector was comprised of a male Fastex-type connector that mated with the female slots in the visor attachment sub-system. All visors were rated poorly for the durability of the stabilizer post and the male connector. The stabilizer post broke easily during trial testing, which then allowed the visor to move independently of the helmet. Many participants rated the male connector poorly for durability due to perceptions about the “plastic” materials used and the associated lack of robustness in prolonged use and in winter temperatures.

While the nasal cutout of the visor was generally rated as “borderline to barely acceptable”, many participants suggested that the cutout should be larger to allow for more ventilation to reduce the likelihood of fogging. The use of the white gasket or spacer around the periphery of the thick visors, between the two layers of polycarbonate, proved to be a visual distraction for participants.

The hinges used in the flat visors were seen as functionally unacceptable and a concern for durability. Most participants indicated that the hinges did not enable the folded visor sides to lie flat and, as a result, the visor remained somewhat bulky for stowage.

4.3 Exit Questionnaire:

Visors were rated as unacceptable for:

- Rifle and Shoulder-fired Weapons Compatibility;
- Stowage (Flat Thin was Borderline);
- Ventilation/Fogging and Thermal Load;
- Durability, Cleaning, and Minor Repairs;
- Blunt Trauma Protection;
- Glare/Haze, Appearance, Detectability; and
- Obstacle Traverse, FIBUA (outside), and Section Attacks.

Thin visors were rated more favourably than Thick visors for:

- Attachment and Adjustment;
- Visual Sharpness and Distortion;
- Physical forces and Comfort; and
- Vehicle Driving.

The Curved Thin visor was rated significantly more favourably than other visors for:

- FOV and Target Detection (viewing to the sides);
- Glare/Haze; and
- Appearance.

Overall, the Curved Thin visor was rated significantly more favourably than all other visors and was the only visor considered acceptable. During focus group discussions, most participants (78%) preferred the Curved Thin visor over the Flat Thin visor (only 22%). The Curved Thick visor proved to be the most disliked visor (83%) due to the resulting loss of visual performance.

Appendix 1 to Annex G: Descriptive Data Summary

Descriptive Data					Significant Differences ($p \leq 0.05$)			
Feature	Visor Type	N	Mean	s.d.	Fthin	Fthick	Cthin	Cthick
Attachment	Flat thin	17	3.7	1.5		√		
	Flat thick	17	1.9	1.2	√		√	
	Curved thin	17	4.5	1.3		√		√
	Curved thick	17	2.9	1.6			√	
Ease of Adjustment	Flat thin	17	3.8	2.0				
	Flat thick	17	2.8	1.8				
	Curved thin	17	3.8	2.1				
	Curved thick	17	2.9	1.9				
Bulk on Head	Flat thin	17	4.6	1.3		√		√
	Flat thick	17	1.8	1.6	√		√	
	Curved thin	17	4.8	1.3		√		√
	Curved thick	17	1.9	1.6	√		√	
Weight on Head	Flat thin	17	4.5	1.2		√		√
	Flat thick	17	1.5	0.9	√		√	
	Curved thin	17	4.8	1.1		√		√
	Curved thick	17	1.6	0.9	√		√	
Eye Fatigue/ Headaches	Flat thin	17	4.8	1.1		√		√
	Flat thick	17	2.7	1.8	√		√	√
	Curved thin	17	4.3	1.3		√		√
	Curved thick	17	2.0	1.7	√	√	√	
Neck Discomfort	Flat thin	17	4.6	1.3		√		√
	Flat thick	17	2.1	1.8	√		√	
	Curved thin	17	4.8	1.1		√		√
	Curved thick	17	2.4	1.8	√		√	
Balance on Head	Flat thin	17	4.5	1.5		√		√
	Flat thick	17	1.5	1.0	√		√	
	Curved thin	17	4.9	1.3		√		√
	Curved thick	17	1.8	1.3	√		√	
Stability on Helmet	Flat thin	17	4.0	1.9		√		√
	Flat thick	17	1.9	1.6	√		√	
	Curved thin	17	4.4	1.4		√		√
	Curved thick	17	2.4	1.8	√		√	
Range of Head Movement	Flat thin	17	3.7	1.7				
	Flat thick	17	2.9	1.9			√	
	Curved thin	17	4.8	1.1		√		√
	Curved thick	17	3.4	1.9			√	
Rifle Compatibility	Flat thin	17	2.8	2.1				
	Flat thick	17	2.4	1.9				
	Curved thin	17	3.1	2.2				
	Curved thick	17	2.5	1.9				
Shoulder Weapon Compatibility	Flat thin	17	2.4	1.9				
	Flat thick	17	1.7	1.2				
	Curved thin	17	2.6	1.9				
	Curved thick	17	1.8	1.3				

Appendix 1 to Annex G: Descriptive Data Summary

Descriptive Data					Significant Differences ($p \leq 0.05$)			
Feature	Visor Type	N	Mean	s.d.	Fthin	Fthick	Cthin	Cthick
Vehicle Driving	Flat thin	17	4.7	1.6		√		
	Flat thick	17	3.5	1.8	√		√	
	Curved thin	17	5.0	1.3		√		
	Curved thick	17	3.8	2.0				
Hatch-up Vehicle Moves	Flat thin	17	4.2	1.6				
	Flat thick	17	3.5	1.6			√	
	Curved thin	17	5.0	1.4		√		
	Curved thick	17	3.6	1.8				
Eyewear Compatibility	Flat thin	17	3.7	2.0				
	Flat thick	17	3.0	1.9				
	Curved thin	17	4.5	1.7				
	Curved thick	17	3.1	1.9				
Personal Stowage	Flat thin	17	4.2	1.7				
	Flat thick	17	3.5	1.9				
	Curved thin	17	3.4	1.4				
	Curved thick	17	2.9	1.4				
Clothing Compatibility	Flat thin	17	4.2	1.6				
	Flat thick	17	3.9	1.7				
	Curved thin	17	4.3	1.7				
	Curved thick	17	3.9	1.8				
Ventilation/ Fogging	Flat thin	17	2.5	1.5				
	Flat thick	17	1.7	1.1			√	
	Curved thin	17	2.8	1.5		√		
	Curved thick	17	2.1	1.5				
Thermal Load	Flat thin	17	2.6	1.5				
	Flat thick	17	2.0	1.2				
	Curved thin	17	2.9	1.7				
	Curved thick	17	2.1	1.2				
Durability	Flat thin	17	2.1	1.5				
	Flat thick	17	1.7	1.1				
	Curved thin	17	2.6	1.9				
	Curved thick	17	2.4	1.5				
Cleaning	Flat thin	17	3.3	2.1				
	Flat thick	17	3.5	2.0				
	Curved thin	17	3.5	1.9				
	Curved thick	17	3.6	1.9				
Minor Repairs	Flat thin	17	3.4	1.5				
	Flat thick	17	3.7	1.6				
	Curved thin	17	3.5	1.8				
	Curved thick	17	3.7	1.7				
Ballistic Protection	Flat thin	17	3.5	1.6				
	Flat thick	17	4.4	1.8				
	Curved thin	17	4.2	1.5				
	Curved thick	17	4.9	1.4				
Blunt Trauma Protection	Flat thin	17	3.2	1.9				
	Flat thick	17	3.0	2.0				
	Curved thin	17	3.5	2.0				
	Curved thick	17	3.1	1.9				

Appendix 1 to Annex G: Descriptive Data Summary

Descriptive Data					Significant Differences ($p \leq 0.05$)			
Feature	Visor Type	N	Mean	s.d.	Fthin	Fthick	Cthin	Cthick
Sand/Dust Protection	Flat thin	17	3.9	2.0				
	Flat thick	17	4.4	2.1				
	Curved thin	17	4.5	1.8				
	Curved thick	17	4.9	1.7				
Sharp Objects Protection	Flat thin	17	5.5	0.8				
	Flat thick	17	5.3	1.2				
	Curved thin	17	5.5	0.9				
	Curved thick	17	5.5	0.8				
Visual Sharpness	Flat thin	17	4.1	1.6		√		√
	Flat thick	17	2.6	1.9	√			√
	Curved thin	17	3.3	1.3				√
	Curved thick	17	1.6	1.5	√	√	√	
Visual Distortion	Flat thin	17	4.5	1.5		√	√	√
	Flat thick	17	2.8	2.0	√			√
	Curved thin	17	3.0	1.1	√			√
	Curved thick	17	1.5	1.1	√	√	√	
Field of View	Flat thin	17	3.7	1.8				
	Flat thick	17	2.5	1.7			√	
	Curved thin	17	4.5	1.5		√		
	Curved thick	17	3.7	1.9				
Nausea	Flat thin	17	4.2	1.8				√
	Flat thick	17	3.8	2.2				
	Curved thin	17	3.8	2.0				
	Curved thick	17	2.6	2.3	√			
Depth Perception	Flat thin	17	4.0	1.7		√		√
	Flat thick	17	2.4	1.9	√			√
	Curved thin	17	3.2	1.4				√
	Curved thick	17	1.4	0.9	√	√	√	
Visual Glare/ Haze	Flat thin	17	1.7	1.0				
	Flat thick	17	1.4	0.6			√	
	Curved thin	17	2.6	1.9		√		
	Curved thick	17	2.5	1.7				
Appearance	Flat thin	17	1.6	1.0				
	Flat thick	17	1.4	0.9				
	Curved thin	17	2.2	1.8				
	Curved thick	17	1.4	0.9				
Camouflage/ Detectability	Flat thin	17	1.5	0.7				
	Flat thick	17	1.2	0.4				
	Curved thin	17	1.5	1.0				
	Curved thick	17	1.2	0.4				
Target Detection (Front)	Flat thin	17	4.3	1.7				√
	Flat thick	17	3.5	1.9				
	Curved thin	17	4.2	1.7				√
	Curved thick	17	3.1	2.1	√		√	

Appendix 1 to
Annex G:
Descriptive Data Summary

Descriptive Data					Significant Differences ($p \leq 0.05$)			
Feature	Visor Type	N	Mean	s.d.	Fthin	Fthick	Cthin	Cthick
Target Detection (Sides)	Flat thin	17	2.7	1.7				
	Flat thick	17	2.1	1.4			√	
	Curved thin	17	3.9	1.7		√		
	Curved thick	17	3.4	2.0				
Obstacle Traverse	Flat thin	17	3.6	1.6				√
	Flat thick	17	2.6	1.5				
	Curved thin	17	3.2	1.5				
	Curved thick	17	2.1	1.3	√			
FIBUA Warfare	Flat thin	17	3.9	1.7				
	Flat thick	17	2.9	1.7				
	Curved thin	17	3.9	2.0				
	Curved thick	17	2.6	1.8				
Section Attacks	Flat thin	17	2.8	1.4				
	Flat thick	17	2.2	1.2				
	Curved thin	17	2.8	1.6				
	Curved thick	17	2.1	1.4				
Night Patrols	Flat thin	17	1.4	1.0				
	Flat thick	17	1.2	0.8				
	Curved thin	17	1.3	1.1				
	Curved thick	17	1.3	1.0				
Riot Control Tasks	Flat thin	17	4.2	1.2				
	Flat thick	17	3.1	1.5				
	Curved thin	17	4.2	1.4				
	Curved thick	17	3.2	1.5				
Overall Rating	Flat thin	17	3.7	1.0		√		√
	Flat thick	17	1.7	0.8	√		√	
	Curved thin	17	4.3	1.5		√		√
	Curved thick	17	1.5	0.8	√		√	

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(U) The incidence of eye and facial injuries has increased over the past century; these injuries can account for a sizeable proportion of casualties. The Clothe the Soldier (CTS) project is developing an integrated two−part system of protection to protect the eyes from low energy fragments, particles, laser, solar and UV radiation (ballistic eyewear) and to protect the eyes and face from high−energy fragments (ballistic visor). A Human Factors 4−dam field trial of a range of visor concepts was conducted at CFB Petawawa over the period 17−20 May, 1999 in order to better understand user requirements, investigate utility and usability issues associated with visor wear across a rage of tasks and conditions and assist in the development of HF−related requirements and design specifications. Twenty regular force infantry soldiers were required to undertake a battery of human factors tests while wearing up to four different visor conditions in a repeated measures design: two protection levels (V50 of 220 m/s and 450 m/s) and two shapes (flat and curved). All tests included a no visor condition as a baseline control. During each test, the order of conditions was balanced among participants. Human factors tests included clinical tests of visual performance, static military vision tests, performance of select obstacle course, range firing, and battle tasks, equipment / weapons / vehicle compatibility clash, and maintainability. Data collection included questionnaires, focus groups, performance measures and HF observer assessments.

Soldiers indicated that the most important assessment criteria for a general−purpose visor were weapon compatibility and visual performance. The visor posed a number of concerns in these areas. Participants rated visor use with the C7A1 rifle as unacceptable due to the slight delay necessary to position the nasal cutout over the rifle butt to achieve a full sight picture. While annoying, participants quickly learned to adjust to the extra head movement needed during sighting to accommodate the visor. Visual performance was another concern among participants. Visual acuity tests confirmed that all of the visors tested produced a small but significant drop in visual performance. While participants did rate the visual performance aspects (e.g. visual sharpness, field of view, distortion, depth perception, etc.) of visors as low, the thin visors were generally rated significantly more favourably than the thick visor designs. In most evaluations, the thick visors were rated as unacceptable. In addition to the visual performance differences between the thin and thick visors, participants also noted additional musculo−skeletal stress and fatigue at the neck associated with the higher load forces imposed by the thick visors. Participants also expressed considerable concern about the ease with which an enemy observer might detect a highly reflective visor. Focus group discussion identified situations for which the Curved Thin visor would be most suitable. A family of visors was recommended to accommodate the range of applications needed. Soldiers also identified a range of modifications to improve weapon compatibility and a host of visual performance parameters.

(U) Au cours du dernier siècle, l’incidence des blessures aux yeux et au visage a augmenté et correspond maintenant à une proportion considérable du nombre total de blessures. Dans le cadre du projet « Habillez le soldat » (HLS), on développe un système intégré à deux parties pour protéger les yeux contre les fragments, les particules et les rayons laser, solaires et UV à faible énergie, (lunettes balistiques) et pour protéger les yeux et le visage contre les fragments à haute énergie (visière balistique).

Un essai sur le terrain de quatre jours pour évaluer des facteurs humains d’une gamme de

concepts de visières a été mené à la BFC Petawawa du 17 au 20 mai 1999 afin de mieux comprendre les exigences de l'utilisateur, d'étudier les questions d'utilité et d'utilisabilité associées au port des visières pour une variété de tâches et de conditions et d'aider dans l'élaboration d'exigences et de spécifications de conception liées à des facteurs humains. Vingt fantassins de la force régulière ont été chargés de mener une batterie d'essais portant sur des facteurs humains pendant qu'ils portaient jusqu'à quatre types de visières différents selon un protocole de mesures répétées : deux niveaux de protection (V50 de 220 m/s et de 450 m/s) et deux formes (plate et incurvée). Tous les essais comprenaient une condition sans visière à titre de contrôle de référence. Pendant chaque essai, l'ordre des conditions était équilibré parmi les participants. Les essais portant sur des facteurs humains comprenaient des essais cliniques de la performance visuelle, des essais d'acuité visuelle statique militaires, la performance sur un parcours du combattant sélectionné, la performance au champ de tir et en tâches de combat, la compatibilité avec l'équipement, les armes et le véhicule et la maintenabilité. La collecte des données s'est faite au moyen de questionnaires, de groupes de discussion, de mesures de performance et d'évaluations par les observateurs des facteurs humains.

Les soldats ont indiqué que les critères d'évaluation les plus importants pour la visière polyvalente étaient la compatibilité avec les armes et la performance visuelle. La visière donnait lieu à un certain nombre de préoccupations à ces égards. Les participants ont jugé l'utilisation d'une visière avec le fusil C7A1 inacceptable à cause du léger retard nécessaire pour positionner l'échancrure nasale par−dessus la crosse du fusil pour obtenir une image viseur intégrale. La performance visuelle était une autre préoccupation parmi les participants. Bien que les participants aient attribué une faible cote aux aspects de performance visuelle (p. ex. acuité visuelle, champ de vision, distorsion et perception tridimensionnelle) des visières, les visières minces ont généralement obtenu une meilleure cote que les visières épaisses. Dans la plupart des évaluations, les visières épaisses ont été cotées inacceptables. En plus des différences de performance visuelle entre les visières minces et les visières épaisses, les participants ont également noté des contraintes et de la fatigue musculo−squelettiques au niveau du cou attribuables aux charges supérieures imposées par les visières épaisses. En outre, les participants ont exprimé beaucoup d'inquiétude au sujet de la facilité avec laquelle un observateur ennemi pourrait détecter une visière à haute réflexion. Seules les visières minces étaient considérées comme une solution acceptable pour une visière polyvalente. Au chapitre des visières minces, le modèle incurvé était préféré (78 % des participants) au modèle plat (22 %).

Les groupes de discussion ont défini des situations auxquelles la visière mince incurvée conviendrait le mieux. Une famille de visières a été recommandée pour répondre à la gamme d'applications nécessaires. Les soldats ont également défini une série de modifications pour améliorer la compatibilité avec les armes et une kyrielle de paramètres de performance visuelle.

14. KEYWORDS, DESCRIPTORS or IDENTIFIERS (Technically meaningful terms or short phrases that characterize a document and could be helpful in cataloguing the document. They should be selected so that no security classification is required. Identifiers, such as equipment model designation, trade name, military project code name, geographic location may also be included. If possible keywords should be selected from a published thesaurus, e.g. Thesaurus of Engineering and Scientific Terms (TEST) and that thesaurus identified. If it is not possible to select indexing terms which are Unclassified, the classification of each should be indicated as with the title.)

(U) Clothe the Soldier; CTS; ballistic visor; visor; ballistic protection; eye protection